Industry & Trade Summary

The Chloralkali Chemicals

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UNITED STATES INTERNATIONAL TRADE COMMISSION

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PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on the chloralkali chemicals covers the period 1992 through 1996 (trade data are reported for 1992-97) and represents one of approximately 250 to 300 individual reports to be produced in this series. Listed below are the individual summary reports published to date on the energy, chemicals, and textiles sectors.

USITC publication number	***Publication date***	***Title***
Energy and Chemicals:		
2458	November 1991	Soaps, Detergents, and Surface-Active Agents
2509	May 1992	Inorganic Acids
2548	August 1992	Paints, Inks, and Related Items
2578	November 1992	Crude Petroleum
2588	December 1992	Major Primary Olefins
2590	February 1993	Polyethylene Resins in Primary Forms
2598	March 1993	Perfumes, Cosmetics, and Toiletries
2736	February 1994	Antibiotics
2739	February 1994	Pneumatic Tires and Tubes
2741	February 1994	Natural Rubber
2743	February 1994	Saturated Polyesters in Primary Forms
2747	March 1994	Fatty Chemicals
2750	March 1994	Pesticide Products and Formulations
2823	October 1994	Primary Aromatics

[1] The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

USITC publication number	*Publication date*	*Title*
Energy and Chemicals--Continued:		
2826	November 1994	Polypropylene Resins in Primary Forms
2845	March 1995	Polyvinyl Chloride Resins in Primary Forms
2846	December 1994	Medicinal Chemicals, except Antibiotics
2866	March 1995	Hose, Belting, and Plastic Pipe
2943	December 1995	Uranium and Nuclear Fuel
2945	January 1996	Coal, Coke, and Related Chemical Products
3014	February 1997	Synthetic Rubber
3021	February 1997	Synthetic Organic Pigments
3081	March 1998	Explosives, Propellant Powders, and Related Items
3082	March 1998	Fertilizers
3093	March 1998	Adhesives, Glues, and Gelatin
3147	December 1998	Refined Petroleum Products
3162	March 1999	Flavor and Fragrance Materials
Textiles and apparel:		
2543	August 1992	Nonwoven Fabrics
2580	December 1992	Gloves
2642	June 1993	Yarn
2695	November 1993	Carpets and Rugs
2702	November 1993	Fur Goods
2703	November 1993	Coated Fabrics
2735	February 1994	Knit Fabric
2841	December 1994	Cordage
2853	January 1995	Apparel
2874	April 1995	Manmade Fibers
3169	March 1999	Apparel

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ABSTRACT

This report addresses industry and trade conditions for the chloralkali chemicals for the period 1992-96, with trade data added for 1997.

- The U.S. chloralkali industry consists principally of about 30 companies operating 65 facilities. Most of these facilities produce either chlorine/caustic soda co-products or soda ash. Chlorine is used in the production of polyvinyl chloride (PVC) (used as an input in construction and consumer products) and other chemicals, as well as many other applications. Caustic soda is used to produce many organic and inorganic chemicals, pulp and paper manufacture, and many other applications. Soda ash is used principally in the production of glass, chemicals, and soaps and detergents. The Gulf Region, especially Texas and Louisiana, has become an increasingly attractive area for chlorine/caustic soda plants because of accessibility to raw materials and relatively low-cost power. In recent years, older, less efficient chlorine/caustic soda plants have been replaced by more modern, larger plants which benefit from economies of scale. The U.S. chlorine/caustic soda industry enjoys competitive advantages over many foreign competitors, and continues to be primarily domestically owned, despite increased foreign activity. However, reflecting growth in foreign chlorine/caustic soda capacity and or increased export orientation, competition from foreign producers, especially in the Middle East and Japan, is increasing.

- In the United States, soda ash is produced from natural sources, primarily trona ore, and production facilities are concentrated in southwestern Wyoming. Outside the United States, however, soda ash is produced primarily by a synthetic process. Because natural soda ash produced in the United States is substantially less expensive to produce than synthetic soda ash, U.S. soda ash producers enjoy a significant competitive advantage over most foreign competitors. This has prompted many foreign firms to participate in the U.S. soda ash industry. As a result, the percentage of the U.S. soda ash industry under foreign ownership rose from zero percent in 1980 to 51 percent in 1996.

ABSTRACT—*Continued*

- Certain end-use applications for chlorine have declined, primarily because of environmental concerns. However, belying earlier predictions that total chlorine use would decline, chlorine consumption increased during 1992-96, generally at a faster rate than demand for its co-product, caustic soda. Industry sources attribute most of this growth to increased demand for PVC plastics used largely in construction. The chlorine/caustic soda industry continues to face public scrutiny over chlorine use and has recently embarked on major research projects assessing the potential toxicity and carcinogenic properties of chlorine chemicals and production processes.

- During 1992-96, the percent of U.S. soda ash production exported rose from 32 to 38 percent. The growth of U.S. exports of soda ash reflects increased demand and the competitiveness of the U.S. industry. U.S. soda ash exporters may, however, face increased competition, especially from China, which has recently expanded production capacity; moreover, U.S. soda ash exporters are facing reduced demand caused by the Asian economic crisis.

- In general, U.S. duty rates for the chloralkali chemicals are significantly lower than comparable duty rates in most other countries. During all or part of the period covered by this summary, U.S. soda ash exporters faced high tariff rates in India, antidumping duties imposed by the European Union and according to the industry, nontariff trade barriers in Japan.

INTRODUCTION

Overview

This industry and trade summary of the chloralkali chemicals[1] covers the portion of the chemical industry producing the co-products *chlorine*[2] and *sodium hydroxide*, as well as other chemicals, including *potassium hydroxide*, *sodium carbonate*, *sodium bicarbonate*, *potassium carbonate*, and *potassium bicarbonate*. Sodium hydroxide, potassium hydroxide, and sodium carbonate are given generic commercial names of *caustic soda*, *caustic potash*, and *soda ash*, respectively. Sodium bicarbonate and potassium bicarbonate are also referred to as sodium hydrogencarbonate and potassium hydrogencarbonate, respectively.

This report addresses developments in the chloralkali industry during 1992-96; however, when necessary to ensure clarity and completeness, references will occasionally be made to developments that occurred outside the period covered by the summary. For example, 1997 trade data have been added to enhance the timeliness of the report. The body of this report contains descriptions of the U.S. and foreign industries producing the chloralkali chemicals and the trade measures affecting these products, as well as analyses of U.S. and foreign markets, U.S. imports, U.S. exports, and the U.S. trade balance.

After a discussion of the chloralkali chemicals in terms of product descriptions, production processes, and uses, the second section of this report, **U.S. Industry Profile**, discusses the characteristics of the U.S. chloralkali industry. Topics that are addressed include the number and type of producers, competitiveness, technology, employment, and degree of globalization. Consumer characteristics, pricing, consumption, foreign dependence, environmental concerns and regulations, and U.S. consumption and production data for the chloralkali chemicals are then described and discussed in the third section, **U.S. Market**. Discussion of environmental concerns is largely focused on chlorine. Such concerns have resulted in cutbacks in some uses for the chemical. However, predictions that total demand for chlorine will decline have not been borne out, as discussed in the **U.S. Market** section of the report. In the fourth section, **U.S. Trade**, a description of U.S. imports and U.S. exports of the principal chloralkali chemicals traded during 1992-97 is provided. Trade is important in the chloralkali industry given that the United States is a major exporter of soda ash and a significant exporter and importer of caustic soda. A discussion of possible reasons for observed trends in international trade for these products and the tariff and nontariff measures affecting imports of chloralkali chemicals to the United States and other countries is also provided. A profile of the foreign chloralkali industry and trends in global chloralkali demand, supply, technology, and competitiveness are addressed in the fifth section, **Foreign Industry Profile**.

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[1] Industry definitions of the chloralkali chemicals differ. For example, two additional products, sodium chlorate and hydrogen chloride, are sometimes included in the grouping of chloralkali chemicals.

[2] Industry terms, italicized the first time they appear in this report, are defined in Appendix B.

In 1996, the three most commercially important products in this summary— chlorine, caustic soda, and soda ash—accounted for about 90 percent of the value of U.S. shipments of the products covered by this summary. In 1997, chlorine, soda ash, and caustic soda were ranked as the eighth, ninth, and tenth largest volume chemicals produced in the United States, respectively.[3] Chlorine, for example, is used to make many other chemicals which are, in turn, used to make thousands of consumer and industrial products that, according to one study, accounted for nearly 40 percent of gross domestic product (GDP) in 1995.[4] However, because of relatively low unit values, especially compared to downstream products, the proportion of chemical industry shipments accounted for by the chloralkali industry does not reflect its importance to the economy.

Description of the Chloralkali Chemicals

This section provides background information on the principal chloralkali chemicals, including product descriptions, production processes, uses, and market characteristics. This background information is intended to provide perspective on discussions of the U.S. and global chloralkali industries and markets presented in subsequent sections of this report.

Chlorine

Chlorine is a heavy, toxic, greenish-yellow gas (Cl_2) at standard temperature and pressure. At low temperatures and high pressures, chlorine becomes a transparent, amber liquid. Because chlorine is a strong *oxidizing agent* that can potentially react explosively with certain other substances, contaminants are, of necessity, kept to a minimum. Chlorine is typically 99.9 percent pure as produced. In contrast to the co-product caustic soda (NaOH), chlorine is generally sold as one grade only. Much of the chlorine produced domestically is used to make downstream products, particularly *ethylene dichcloride* (*EDC*); EDC is then used to produce *vinyl chloride monomer* (*VCM*), a precursor in the production of *polyvinyl chloride* (*PVC*). Chlorine is also used as a bleaching agent in the pulp and paper industry and as a disinfectant in water treatment. A flow chart showing the products made from chlorine is presented in figure 1. Chlorine that is not consumed internally on-site is generally shipped to consumers in liquid form, primarily via pressurized rail cars.[5]

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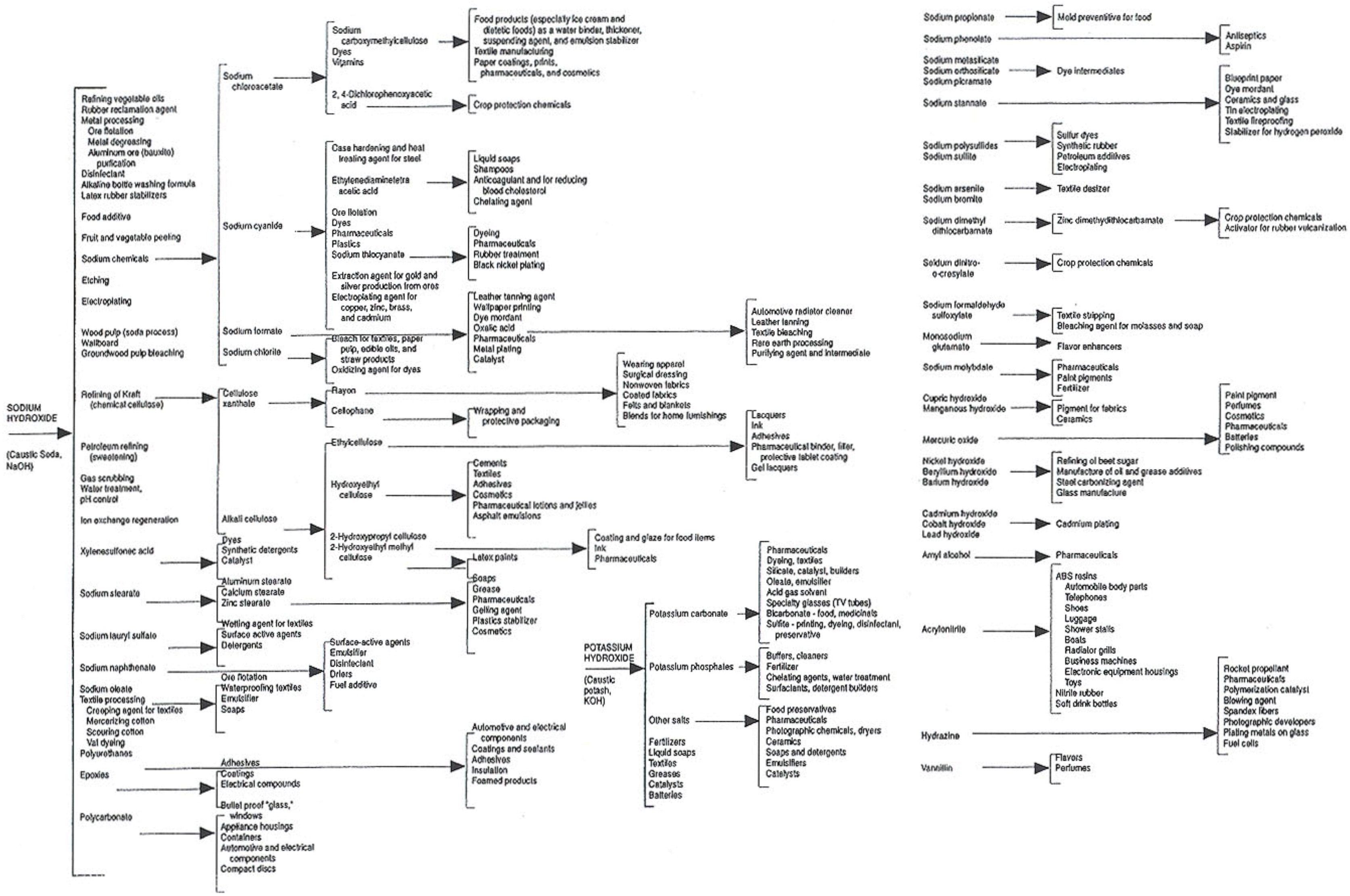
[3] Chemical Manufacturers Association (CMA), *U.S. Chemical Industry Statistical Handbook, 1998*, Sept. 1998, p. 40.

[4] CMA, Chlorine Chemistry Council, *Chlorine and Its Major End Uses*, Mar. 1995, p. 2.

[5] According to a publication, about 70 percent of liquid chlorine was shipped by rail, 20 percent by pipeline, and 7 percent was shipped by barge. (Kirk-Othmer, *Encyclopedia of Chemical Technology*, Fourth Edition, Volume 1, 1991, p. 1003.)

Figure 2
Sodium and potassium hydroxide chemistry and product trees



Source: Ron Whitfield, Charles River Associates. Reprinted with permission of Charles River Associates.

Although not an *alkali*, chlorine is generally classified together with the alkalis because it is usually produced as a co-product with caustic soda in the electrolysis of sodium chloride (table salt) *brine*.[6] The chemical reaction is shown below:

$$\underbrace{2Na^{+} + 2Cl^{-} + 2H_2O}_{\text{(brine)}} \text{ ----> } \underset{\substack{\text{(chlorine)}\\ \text{gas}}}{Cl_2} + \underset{\substack{\text{(hydrogen)}\\ \text{gas}}}{H_2} + \underset{\text{(caustic soda)}}{2NaOH}$$

The primary products of the reaction, in terms of commercial value, are chlorine and caustic soda. These two co-products are produced in fixed ratios; the relative weight of caustic soda to chlorine produced is about 1.1. When demand for one co-product exceeds that for the other, the producer is obliged to dispose of the co-product that cannot be sold as readily. As a result, the prices of chlorine and caustic soda have been known to swing sharply. In most cases, chloralkali production is geared to chlorine demand rather than to caustic soda demand; however, there may be exceptions to that rule.

Three types of electrolytic cells are used to produce chlorine and caustic soda—mercury cells, diaphragm cells, and membrane cells. In the United States, the preponderance of caustic soda and chlorine currently manufactured is produced from diaphragm cells.[7] While production of chlorine and caustic soda in any of these three types of electrolytic cells is highly energy and capital intensive,[8] the three processes vary significantly in terms of the quality of product and environmental suitability. For example, the mercury cell process tends to produce a relatively pure caustic soda product but suffers from a major environmental disadvantage in that mercury waste is formed. A disadvantage of the diaphragm cell process is that the caustic soda produced is less concentrated and contains more salt than that produced in a mercury or membrane cell. The membrane cell process, in which a membrane is used to select the flow of ions, is considered to be the most technologically promising and is the focus of much research and development (R&D) in improving cell technology. Most of the new chloralkali plants being constructed are based on this type of technology.[9]

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[6] More than 95 percent of the chlorine produced in the United States is obtained from the electrolysis of sodium chloride brine. Other processes that account for the remainder of chlorine production include byproduct production. Some paper mills may produce chlorine internally for use as a bleaching agent. A small percentage of the caustic soda produced in the United States is derived from soda ash using a non-electrolytic chemical process that does not produce chlorine (the lime soda process).

[7] According to data provided by the Chlorine Institute, the percentage of domestic chlorine production supplied by diaphragm cells declined only slightly during 1992-96, falling from 77 percent to 76 percent. During that period, the percentage of chlorine produced in membrane cells rose from 7 percent to 10 percent while the percentage of chlorine produced in mercury cells fell from 14 percent to 13 percent.

[8] Energy accounts for about 70 percent of the cost of chlorine/caustic soda production (*Chemical Week*, Feb. 7, 1996, p. 28).

[9] *Chemical and Engineering News*, Oct. 20, 1997, p. 20.

Caustic Soda

At standard temperature and pressure, caustic soda exists as a white, *deliquescent* solid. More than 90 percent is sold and shipped in aqueous solution; the remainder is shipped as a solid. Applications for caustic soda are even more widespread than for chlorine. As with chlorine, much of the caustic soda produced is used in the manufacture of organic and inorganic chemicals. Chemicals made from caustic soda include propylene oxide, polycarbonates, ethylene amines, epoxy resins, and hypochlorites. Caustic soda is also used in the manufacture of pulp and paper, soaps and detergents, aluminum, textiles, and in chemical processes such as water treatment. A flow chart showing the principal products of caustic soda and of the related chemical, caustic potash, is shown in figure 2.

Soda Ash

Sodium carbonate, commonly called soda ash, exists as a grayish white, *hygroscopic* powder. Solutions of soda ash are strongly alkaline but far less corrosive than caustic soda. There are three principal grades of soda ash (*dense soda ash*, *intermediate soda ash*, and *light soda ash)*. Soda ash's principal uses are in the manufacture of glass, chemicals, soaps and detergents, and pulp and paper, as well as in water treatment.

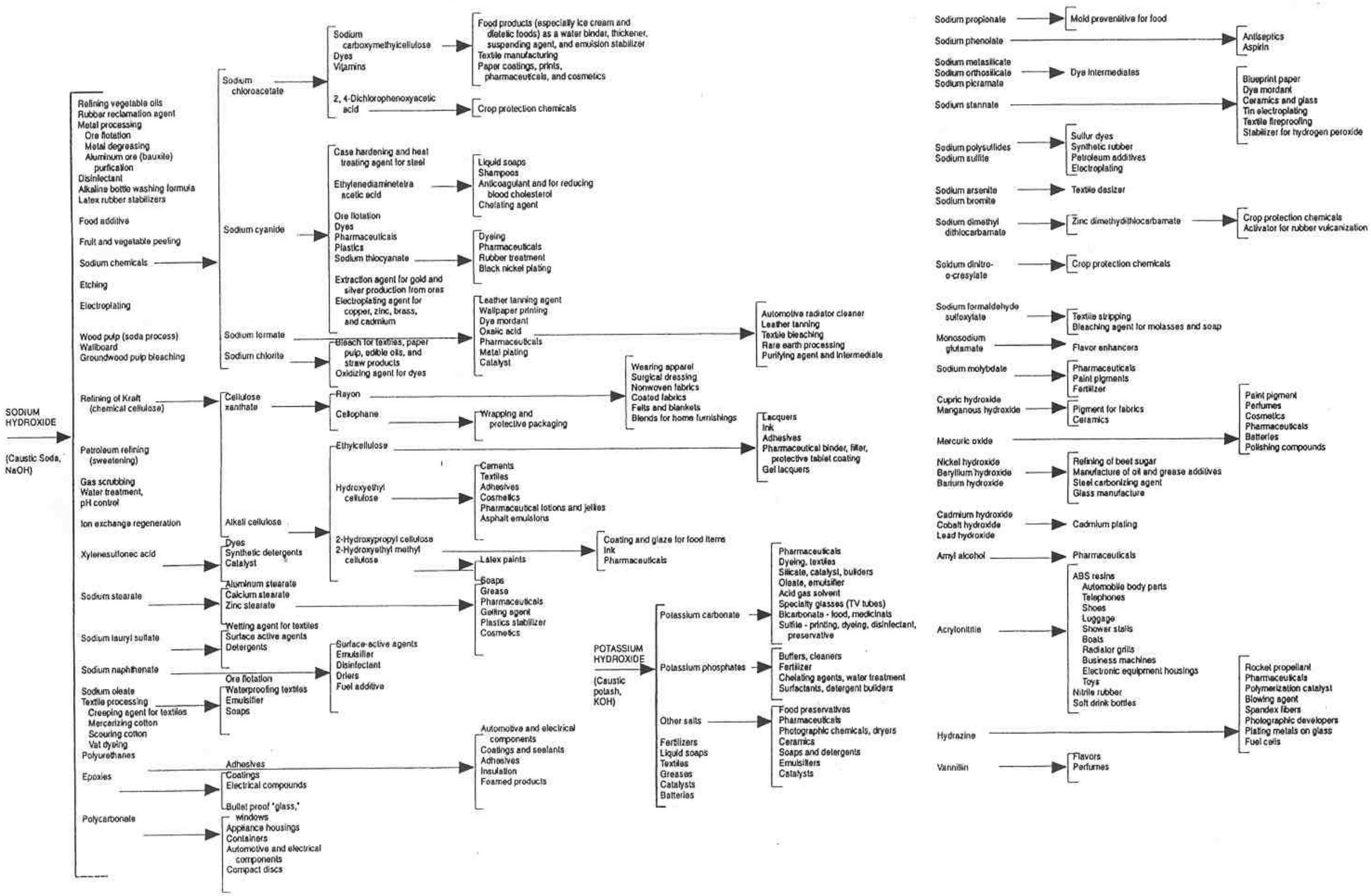
In the United States, where the largest reserves of natural soda ash in the world are found, soda ash is produced exclusively from natural sources, principally from *trona* deposits located in southwestern Wyoming but also from carbonate-rich brines located in California. Trona is a hydrated, mixed salt of sodium carbonate and sodium bicarbonate. In most countries other than the United States, soda ash is produced *synthetically* by a significantly more expensive process (usually the *Solvay* process or a variation of the Solvay process).

Other Chloralkali Chemicals

Caustic potash (potassium hydroxide) is produced by the electrolysis of potassium chloride (potash), a process that is similar to the production of caustic soda. Caustic potash is used to prepare other potassium chemicals and soaps. The most important potassium chemical prepared from caustic potash is potassium carbonate. Consumption of this chemical is increasing because of its use in the manufacture of video glass for color TVs and computer monitors. Figure 2 shows some of the other end uses for potassium hydroxide.

Sodium bicarbonate, also referred to as baking soda, is made synthetically by passing carbon dioxide through a saturated solution of soda ash or sodium sesquicarbonate. It is also made in a less pure form as a byproduct of the Solvay process for soda ash production. Many of the uses of sodium bicarbonate relate to its mildly alkaline properties, which enable it to be used in animal feeds and in many household and industrial products.

Figure 2
Sodium and potassium hydroxide chemistry and product trees



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U.S. INDUSTRY PROFILE

Industry Structure[10]

General

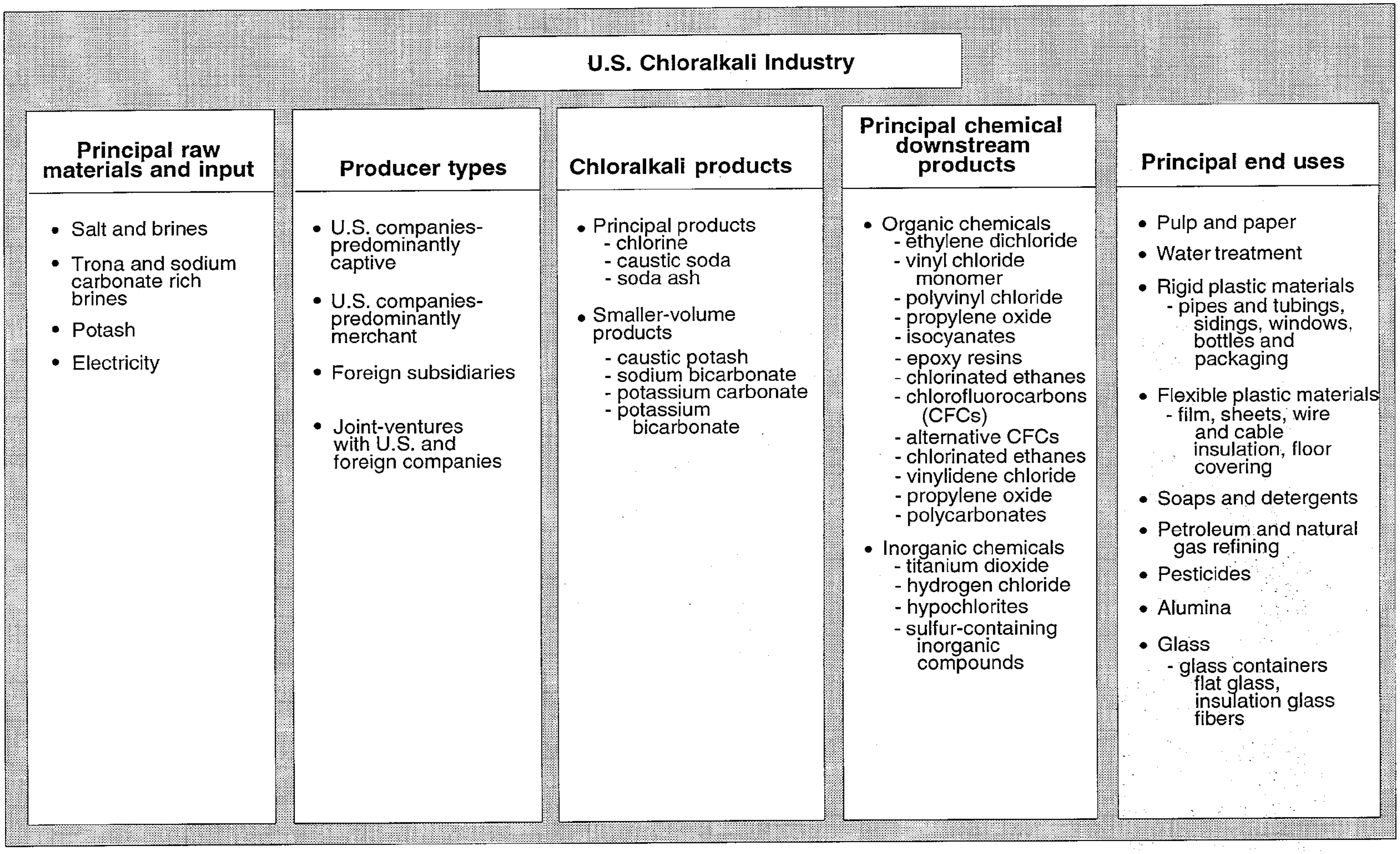
In early 1996, the U.S. chloralkali industry consisted principally of about 30 companies operating approximately 65 facilities and producing principally either chlorine/caustic soda or soda ash.[11] Chlorine/caustic soda facilities are concentrated in the Gulf States and the Pacific Northwest. The Gulf States, especially Texas and Louisiana, have become an increasingly attractive area for chlorine/caustic soda plants because of proximity to sources of raw materials and feedstocks such as salt and ethylene (used to produce EDC) and relatively low-cost power. Most soda ash facilities in the United States are concentrated near trona deposits in southwestern Wyoming. Nearby deposits of coal are available to generate low-cost energy. Figure 3 summarizes the structure of the U.S. chloralkali industry by listing the major types of producers and products for the industry and the principal end uses. Figure 4 shows the location of selected chloralkali facilities in the United States and Canada.

According to the *Annual Survey of Manufactures,* compiled by the Bureau of the Census (Census), the estimated total number of employees (including production workers) active in the synthetic chloralkali industry (SIC 2812), excluding soda ash and other mined alkalis, declined by 26 percent during 1992-96 from about 8,000 to about 5,900. The number of production workers also declined by 26 percent, from about 5,400 to about 4,000. In contrast to the figures reported by Census, the Chlorine Chemistry Council reports that the total number of employees involved in producing chlorine/caustic soda amounted to 30,500

[10] The products covered in this summary correspond to Standard Industrial Classification (SIC) code 2812, except for soda ash mining and other alkalis produced by mining, which are classified in SIC 1474.

[11] The data were obtained from a number of trade publications dealing with chloralkali. Given that a number of companies are owned by two or more partners, that ownership patterns are changing constantly, and that some smaller facilities may not be reported, these estimates are likely to be low.

Figure 3
U.S. chloralkali industry: Principal raw materials and inputs; producer types; chloralkali products; principal chemical downstream products; and principal end uses



Source: Compiled by staff of the U.S. International Trade Commission.

Figure 4
Operating chlorine and alkali plants in the United States and Canada, January 1996

Source: The Chlorine Institute, Inc. Modified by staff of the U.S. International Trade Commission. Reprinted with permission of The Chlorine Institute.

in 1995.[12] Mine and plant employment data in the U.S. soda ash industry as reported by the U.S. Geological Survey remained relatively constant at about 2,800 during 1992-96.[13]

Data provided in the *Annual Survey of Manufactures* indicate that the annual level of productivity for the synthetic[14] chloralkali industry (defined in this report as value of industry shipments per production worker) increased in nominal terms from about $516,000 per production worker in 1992 to about $712,000 per production worker in 1996.[15] Average annual wage rates per production worker increased from an average of about $43,000 in 1992 to about $49,000 in 1996. Despite rising wages, labor cost considerations are not an important factor in U.S. global competitiveness, according to an industry source, because the chlorine/caustic soda industry is capital intensive, not labor intensive.

The chloralkali industry is relatively mature. Significant R&D expenditures are made for health, safety, and environmental research, largely because of the hazards and concerns associated with chlorine and its downstream products. R&D in the chlorine/caustic soda industry has also focused on electrolytic cell design and the recycling of chlorine-containing products such as hydrogen chloride.[16] R&D in the soda ash industry has focused on developing more efficient production techniques to increase mining yields, especially in the area of solution mining.

Chlorine and Caustic Soda

During 1970-90, U.S. producers increased the capacity of the typical U.S. chlorine/caustic soda plant, shutting down smaller, less efficient plants and increasing capacity in the Gulf States region. This trend was intensified during 1990-95. The following tabulation illustrates some of the principal structural changes that occurred in the U.S. chlorine/caustic soda industry during 1970-95.[17]

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[12] Staff conversation with Keith Christman, economist at the Chlorine Chemistry Council, Chemical Manufacturers Assoc., Apr. 1996. The latter number at first appears inconsistent with the much lower figure (5,900) reported by Census in 1996. According to a Census official, the apparent discrepancy is resolved when it is realized that Census defines an industry in terms of the predominant product produced in a particular facility. Thus, facilities producing chloralkali *and* downstream products which derive most of their revenues from the downstream products are classified by Census in terms of the industry producing the downstream products. This implies that only a fraction of the establishments producing chlorine/caustic soda during 1996 (5,900/30,500 or about one-fifth) were *primarily* engaged in that activity. According to a source in a trade journal, about two-thirds of the chlorine produced in the industry was used captively (*Chemical Week*, Feb. 7, 1996, p. 28).

[13] U.S. Geological Survey, *Mineral Commodity Summaries, 1997.*

[14] According to a conversation with a Census official, in order for a chemical product to be defined as synthetic in the Current Industrial Reports, it must be produced from starting materials which are reacted chemically.

[15] These figures were not adjusted for inflation.

[16] A characteristic of the chlorine/caustic soda industry is that much of the technology is developed by companies that license their technology to the producers. According to an industry source, there are about 8 companies which license membrane technology to U.S. chloralkali producers.

[17] *Chemical Week*, Nov. 22, 1995, pp. 25-28.

	1970	1980	1990	1995
Average plant size (short tons[18]/day)	404	489	577	792
Number of U.S. producers	38	34	26	25
Number of plant sites	70	64	52	45
Percentage production in Gulf States	55	61	68	70

During 1992-96, the production capacity of the U.S. chlorine industry rose by 8 percent from 35,594 short tons/day to 38,416 short tons/day.[19] Despite this growth in capacity, the effective capacity utilization rate of the U.S. chlorine industry amounted to close to 100 percent in 1995 and 1996 according to some sources.[20]

Recently announced chlorine capacity increases reported in trade journals are scheduled to take place in facilities located in Lake Charles, LA; Freeport, TX; McIntosh, AL; Baytown, TX; Geismar, LA; and Point Comfort, TX.[21] Altogether, capacity expansions announced by the industry that are expected to be installed by 1999 are projected to amount to about 2.6 million short tons per year,[22] resulting in a percentage capacity increase relative to 1996 of about 20 percent. To reduce costs and risks, many of these capacity additions will involve process improvements and addition of cell units to existing facilities rather than building new chlorine/caustic soda plants.[23] Some analysts have expressed their concern that too sharp a capacity increase could lead to an oversupply of chlorine. Such an oversupply situation could also be exacerbated by recent improvements in recycling technology for chlorine-containing products (e.g., hydrogen chloride), which could reduce demand for newly manufactured chlorine.

Table 1 shows key U.S. chlorine/caustic soda plants operating in the United States and their locations and estimated annual capacities as of about May 1996.[24] The top six companies, Dow Chemical, Occidental Chemical, PPG Industries, Formosa Plastics, Olin, and Vulcan, with at least 22 facilities, accounted for about 80 percent of U.S. chlorine/caustic soda capacity in early 1996.[25] Dow Chemical and Occidental Chemical were the two largest chlorine/caustic soda producers, together accounting for about half of U.S. capacity. Dow uses more than 90 percent of the chlorine it produces captively; consequently, Occidental was the larger producer of chlorine for the merchant market.[26] Trade journals list about 20 smaller chlorine/caustic soda producers, none of which has a capacity greater than 500,000

[18] A short ton is 2,000 pounds, avoirdupois, or 0.9072 metric tons.

[19] The Chlorine Institute, *North American Chlor-Alkali Industry Plants and Production Data Report-1996*.

[20] *Chemical Week*, Feb. 26, 1997, p. 56.

[21] Ibid., pp. 55-60.

[22] Ibid.

[23] *Chemical and Engineering News*, Jan. 1, 1996, pp. 12-13.

[24] Roger Shamel, *The Global Chloralkali Industry*, presentation at the *Chloralkali Industry, Update and Forecast* symposium, sponsored by Consulting Resources Corp. and Chemical Week, May 29-30, 1996. The reported capacities of the U.S. chlorine/caustic soda industry vary slightly for different sources.

[25] Ibid.

[26] C*hemical Marketing Reporter*, Sept. 16, 1996, p. SR7. The publication's name was changed to the C*hemical Market Reporter* in October 1996.

Table 1
Key U.S. chlorine/caustic soda producers, location, and estimated capacities, 1996

Company and location	Estimated annual capacity: Chlorine	Estimated annual capacity: Caustic soda
	))))))) 1,000 short tons	*))))))*
Dow:		
Freeport, TX	2,250	2,345
Plaquemine, LA	1,185	1,305
Subtotal	**3,435**	**3,650**
Occidental Chemical:		
Convent, LA	372	409
Corpus Christi, TX	460	507
Deer Park, TX	383	422
Delaware City, DE	139	103
La Porte, TX	529	583
Mobile, AL	45	-
Muscle Shoals, AL	146	65
Niagara Falls, NY	323	356
Tacoma, WA	215	237
Taft, LA	640	704
Subtotal	**3,252**	**3,386**
PPG:		
Lake Charles, LA	1,241	1,365
Natrium, WV	392	431
Subtotal	**1,633**	**1,796**
Formosa:		
Baton Rouge, LA	198	218
Point Comfort, TX	615	677
Subtotal	**813**	**895**
Olin:		
Augusta, GA	112	123
Charleston, TN	260	286
McIntosh, AL	402	442
Subtotal	**774**	**851**
Vulcan:		
Geismar, LA	268	290
Port Edwards, WI	76	65
Wichita, KS	263	290
Subtotal	**607**	**645**
Key producers subtotal	**10,514**	**11,223**
Other	2,636	2,819
Total United States	**13,150**	**14,042**

Source: Reprinted with permission of Consulting Resources Corporation.

short tons per year. As much of the chlorine produced is used captively by U.S. chlorine/caustic soda producers to make downstream products (as noted earlier, the industry average in early 1996 was about two-thirds),[27] there is significant vertical integration for U.S. chlorine production.

A number of the companies operating in the chlorine/caustic soda industry are multinational. For example, U.S. companies Dow Chemical and Occidental Chemical have chloralkali facilities in Canada, Germany, and Brazil, and Thailand, Chile, and Brazil, respectively. Foreign companies that have chlorine/caustic soda operations in the United States include a French company, Elf Atochem, and a Taiwanese company, Formosa Plastics. Chlorine/caustic soda joint ventures that are either operating or being planned in the United States are less prevalent than in some other industries, such as the U.S. soda ash industry as discussed below, and those that are being set up are instituted because of interest in the downstream products, e.g., EDC or PVC, rather than in the chloralkali chemicals themselves. Although the U.S. chlorine/caustic soda industry has seen increased foreign ownership, it is still predominantly owned and operated by U.S.-based firms (at least 88 percent in 1997, according to one industry estimate).

Soda Ash

In 1996 there were six natural soda ash producers in the United States.[28] Five of these producers (FMC Wyoming Corp., General Chemical Corp., OCI Chemical Corp., Solvay Minerals Inc., and Tg Soda Ash Inc.) mined trona in Green River or Granger, WY. One producer, North American Chemical Co., produces soda ash from lake brine in Trona, CA. The total capacity of the U.S. soda ash industry in 1996 was 13.3 million short tons. Table 2 shows the U.S. soda ash plants operating in the United States and their locations, estimated capacities, source of sodium carbonate, and ownership profile for 1996.

There has been a sharp increase in foreign ownership of the U.S. soda ash industry. During 1980-90, foreign ownership rose from practically zero to 37 percent; by early 1996, slightly more than half (50.9 percent) of the U.S. soda ash industry was foreign-owned.[29] Foreign companies, including foreign glass and soda ash manufacturers typically have invested in the U.S. soda ash industry by forming joint ventures with domestic companies. In three cases, foreign firms in 1996 owned a majority share or 100 percent of these companies. Foreign partners include chemical producers and soda ash consumers (especially glass producers) from Australia, France, Belgium, South Korea, and Japan.

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[27] *Chemical Week*, Feb. 7, 1996, p. 28.

[28] There were 10 synthetic soda ash plants operating in the United States in the late 1930s and 1940s. The last synthetic soda ash plant was shut down in 1986 (U.S. Bureau of Mines, *Annual Report, Soda Ash: 1992*).

[29] Dennis Kostick, U.S. Geological Survey, presentation at the *Chloralkali Industry, Update and Forecast* symposium, sponsored by Consulting Resources Corp. and *Chemical Week*, May 30, 1996.

Table 2
U.S. soda ash producers, location of plants, estimated production capacities, source of sodium carbonate, and ownership profile, 1996

(*Million short tons per year, unless otherwise noted*)

Company	Plant nameplate capacity	Plant location	Source of sodium carbonate
FMC Wyoming Corp.[1]	3.55	Green River, WY	Underground trona
General Chemical (Soda Ash) Partners[2]	2.40	Green River, WY	Underground trona
North American Chemical Co.[3]	1.45	Trona, CA	Dry lake brine
OCI Chemical Corp.[4]	2.30	Green River, WY	Underground trona
Solvay Minerals Inc.[5]	2.30	Green River, WY	Underground trona
Tg Soda Ash Inc.[6]	1.30	Granger, WY	Underground trona
Total	13.30		

[1] A joint venture between FMC Wyoming Corp. (80%) and the Japanese companies Sumitomo Corp. and Nippon Sheet Glass Co., Ltd. (20%), formed in Feb. 1996.
[2] A joint venture between General Chemical Corp. (51%), Australian Consolidated Industries International (ACI-25%), and Tosoh Wyoming Inc. of Japan (24%), which purchased part of ACI's share in June 1992.
[3] The equity share of Oriental Chemical Industries was reduced from 27% to about 7% in 1993.
[4] Rhone-Poulenc of France sold its 51% share to Oriental Chemical Industries Co. Ltd. (OCI) of Korea on Feb. 29, 1996; Union Pacific Resources Co. owns 49%.
[5] Solvay Soda Ash Joint Venture is owned by Solvay S.A. of Belgium (80%) and Asahi Glass Co. of Japan (20%), which became a partner in Feb. 1990. Capacity increase of 300,000 short tons per year was installed Dec. 1995.
[6] Owned by Texasgulf Inc., subsidiary of Societe Nationale Elf Aquitaine of France (100%).

Source: U.S. Geological Survey, Soda Ash, Annual Review-1996.

During 1992-96, demand for U.S.-origin soda ash increased, but in contrast to chlorine, this increased demand was driven primarily by growth in export markets. Reflecting this increased demand during 1994-95, the capacity utilization rate for the U.S. soda ash industry rose from 85 percent to 89 percent. However, in late 1995 and 1996, FMC and Solvay increased their combined soda ash capacity by close to a million short tons per year, resulting in a decline in capacity utilization rate of the industry to about 85 percent in 1996. Solvay announced plans to further increase its capacity by over a million short tons, in part to replace capacity that will be shut down by its joint-venture partner, Asahi Glass Co., in Chiba, Japan.[30] Because of rationalization, some foreign producers are shutting down their relatively inefficient synthetic soda ash plants. Future demand in these areas will largely be supplied by natural soda ash exports from the United States. According to an industry analyst, 11 foreign soda ash facilities with a total capacity of 2.5 million metric tons[31] per year were shut down during January 1992-June 1997.[32]

[30] U.S. Geological Survey, *Soda Ash Annual Review-1996*. However, according to an industry observer, because of recent concerns that the industry is experiencing overcapacity, some of the announced expansions of the U.S. soda ash industry will be scaled back or delayed.
[31] A metric ton is 1,000 kilograms or approximately 1.1023 short ton.
[32] Charles Raleigh and Peter Harben, *Soda Ash Goes Global for Growth*, First International Soda Ash Conference, Rock Springs, WY, June 11, 1997.

Other Chloralkali Chemicals

U.S. shipments of chloralkali chemicals other than chlorine, caustic soda, and soda ash are significant. In 1996, such shipments were valued at $394 million, or about 10 percent of the value of total chloralkali shipments (including natural soda ash) in the United States.[33] Caustic potash, potassium carbonate, and sodium bicarbonate accounted for most of this value.

In June 1996, caustic potash was produced in the United States by 3 producers operating 5 plants with a total capacity of about 500,000 short tons per year,[34] or in comparison, about 4 percent of the capacity of the U.S. caustic soda industry. In April 1998, four U.S. producers of potassium carbonate, a derivative of caustic potash, operated 4 plants with a total capacity of about 183,000 short tons per year.[35] Capacity was recently added both by the former sole producer (Armand Products, a joint venture between Occidental Chemical and Church and Dwight) and three other companies in anticipation of increased demand for potassium carbonate in the U.S. and export markets for glass used in TVs and computer monitors. However, the capacity increases may have exceeded growth in demand and the industry appears to be experiencing overcapacity.[36]

In early 1996, sodium bicarbonate (baking soda) was produced in the United States by 5 companies operating 6 facilities with a total U.S. production capacity of about 700,000 short tons per year.[37] The product is produced synthetically from soda ash, from natural sodium bicarbonate (nahcolite) mined in Colorado, and from material produced from trona. The largest U.S. sodium bicarbonate producer is Church and Dwight, which packages sodium bicarbonate under the Arm and Hammer trademark. R&D has been conducted to find new or expanded uses for sodium bicarbonate, including personal care and household applications such as toothpastes, carpet deodorizers, laundry detergents, and antiperspirants. Installation of new capacity reduced the operating rate for the industry to about 75 percent in late 1996.[38]

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[33] Bureau of the Census, Current Industrial Reports, *Annual Report on Inorganic Chemicals-1996*; U.S. Geological Survey, *Soda Ash Annual Review-1996*.

[34] Mannsville Chemical Products Corp., *Chemical Products Synopsis: Caustic Potash*, June 1996.

[35] Mannsville Chemical Products Corp., *Chemical Products Synopsis: Potassium Carbonate*, Apr. 1998.

[36] Ibid.

[37] Mannsville Chemical Products Corp., *Chemical Products Synopsis*: *Sodium Bicarbonate*, Feb. 1996.

[38] *Chemical Marketing Reporter*, Sept. 16, 1996, p. SR17.

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Table 3 shows estimated overall chloralkali shipment and apparent consumption data during 1992-96, in millions of dollars, as provided by the U.S. Department of Commerce (DOC) and the U.S. Geological Survey.

Table 3
Chloralkali chemicals: Shipments and apparent consumption, 1992-96; exports of domestic merchandise and imports for consumption, 1992-97; and imports to consumption ratio and exports to shipments ratio, 1992-96

Year	Shipments[1]	Exports	Imports	Apparent consumption	Imports/ consumption	Exports/ shipments
	Millions of dollars				*Percent*	
1992	3,598	803	170	2,965	6	22
1993	3,012	598	125	2,539	5	20
1994	2,999	594	149	2,554	6	20
1995	3,998	899	210	3,309	6	23
1996	4,138	967	188	3,359	6	23
1997	([2])	824	184	([2])	([2])	([2])

[1] Shipments value data were estimated by adding shipment value data for product code 2812 in the Current Industrial Report, M28A, Bureau of the Census, to production value data for soda ash compiled by the former Bureau of Mines during 1992-95 and the U.S. Geological Survey in 1996 and thereafter.
[2] Data were not available at the time of preparation of the report.

Source: Compiled from official statistics of the U.S. Department of Commerce and the U.S. Geological Survey.

Trade data are shown for 1992-97. Also shown is the percent ratio of imports to apparent consumption and the percent ratio of exports to shipments.

During 1992-94, U.S. shipments of the chloralkali chemicals declined steadily from $3.6 billion to $3.0 billion, but then rebounded to $4.1 billion in 1996. Exports declined during 1992-94 from $803 million to $594 million, rose during 1994-96 to $967 million, but then fell to $824 million in 1997. Imports fluctuated during 1992-97, ranging from $125 million to $210 million. The percentage of apparent consumption accounted for by imports remained relatively steady during the 1992-96 period, ranging from 5 to 6 percent, while the percentage of chloralkali production exported was much higher, ranging between 20 and 23 percent. The decline in the value of shipments for the chloralkali chemicals during 1992-94 appears principally related to a decline in the unit value of caustic soda shipments; the decline in the value of exports for the chloralkali chemicals during that period appears principally related to a decline in the quantity and unit value for caustic soda exports and a decline in the unit value of soda ash exports, which will be discussed further. The competitive strength of the

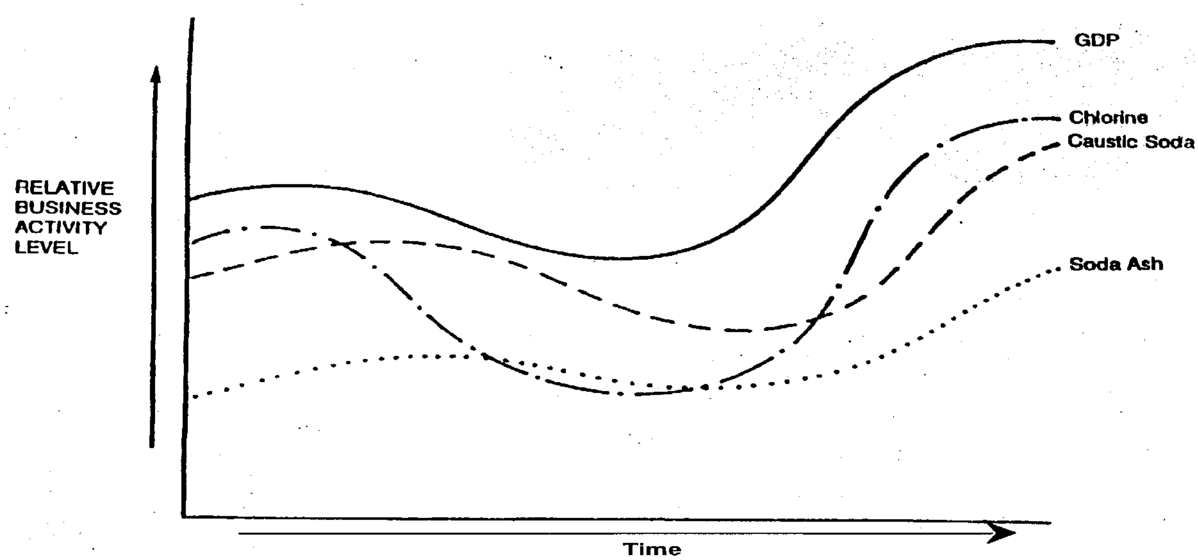
U.S. industry is illustrated by the fact that U.S. exports exceeded U.S. imports by a substantial margin during the period covered by the summary.

Consumer Characteristics and Factors Affecting Demand

In contrast to chlorine, which is mostly used captively, a fairly high percentage of caustic soda and soda ash is produced for merchant sale. Larger industrial users tend to purchase directly from the manufacturer, while smaller firms are supplied by distributors. The percentage of caustic soda sales handled by distributors has increased during the past decade, partly in response to the downsizing of sales and marketing personnel by U.S. producers.[39] As noted previously, chlorine/caustic soda producers tend to run their facilities to meet chlorine demand, so that caustic soda production is often determined by demand for its co-product.

Because chlorine demand is dependent to a significant extent on PVC use, which, in turn, is largely dependent on the level of construction activity, chlorine demand tends to be more cyclical than demand for the caustic soda co-product. The latter is dependent on more varied and less cyclically dependent end-use sectors. Soda ash shows less cyclical variation than either chlorine or caustic soda because demand for soda ash is largely dependent on demand for glass, an end use which does not fluctuate as sharply with changes in business

Figure 5
Chloralkali demand in relation to the business cycle



Source: Roger Shamel, Consulting Resources Corp., May 1996. Reprinted with permission of Consulting Resources Corp.

[39] Jack Clinton, *Now that You Are Going to Make All this New Chlorine, What Will You Do With the Caustic?* Presentation before the 1997 World Petrochemical Conference, March 18-20, 1997.

activity.[40] Figure 5 shows schematically the relative demand for chlorine, caustic soda, and soda ash corresponding with relative "business activity levels" characteristic of the United States and other advanced market economies.[41]

The Impact of Environmental Concerns and Regulations

Although total chlorine demand has grown in recent years largely because of strong demand for PVC, environmental concerns about chlorine and its downstream products and byproducts have played a significant role in reducing demand for certain applications for chlorine including its use in pulp and paper bleaching[42] and in the production of *chlorofluorocarbons* (*CFCs*) and chlorinated solvents.[43] Environmental concerns have probably had the greatest impact on chlorine/caustic soda producers in the Pacific Northwest because many pulp and paper plants in that area which previously relied on elemental chlorine have converted to

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[40] Glass consumption is not, however, immune to business cycle trends. Flat glass consumption, in particular, is dependent on new construction and automobile production.

[41] Roger Shamel, *The Global Chloralkali Industry*, presentation at the *Chloralkali Industry, Update and Forecast* symposium, sponsored by Consulting Resources Corp. and *Chemical Week*, May 29-30, 1996.

[42] The estimated percentage of U.S. chlorine consumption used in pulp bleaching declined from 16 percent in 1988 to 7 percent in 1996, reflecting the impact of environmental factors (Mannsville Chemical Products Corp., *Chemical Products Synopsis*). This phasing out which was initially largely voluntary is increasingly becoming mandatory. For example, the Environmental Protection Agency (EPA) has recently issued regulations which will have the effect of phasing out the use of elemental chlorine in pulp bleaching (*Chemical and Engineering News*, Nov. 24, 1997, p. 15).

[43] Some environmentalists contend that virtually all chlorine products are potentially hazardous and therefore all chlorine production should be phased out. For example, in 1992, the International Joint Commission of Great Lakes Water Quality, a U.S.-Canada environmental oversight group, called for the phased elimination of chlorine and chlorine-containing compounds as industrial feedstocks (*Chemical Marketing Reporter*, Oct. 18, 1993, p. 5 and following). (This recommendation was later modified.) Currently, this approach is not being considered, although the EPA has requested that Congress authorize a comprehensive toxicity study of chlorine and chlorine derivatives. Other environmentalists seek to identify those downstream products or byproducts of chlorine production or of its downstream products for which there is more definitive scientific evidence to justify concern. These more limited concerns dealing with specific chlorine-related products and processes have resulted in reduced demand for specific end-use applications for chlorine as noted above. For example, the use of chlorine in pulp bleaching declined in large part because of concern about the production of dioxin, a toxic byproduct known to cause cancer in laboratory animals. The environmental organization Greenpeace contends that other chlorine-related applications including PVC production and incineration are linked to the release of dioxin (*Chemical Week*, Apr. 16, 1997, p. 8). Another area of concern is related to the discovery that chlorofluorocarbons (CFCs) likely contribute to the reduction of the levels of atmospheric ozone, which is known to block harmful ultra-violet rays from penetrating the atmosphere. Following the accumulation of evidence indicating that atmospheric ozone has declined, an agreement was reached under the Montreal Protocol to phase out CFC production. Under an agreed accelerated schedule for the Montreal Protocol, CFC production in the United States has been largely eliminated but production was replaced by other chlorine-based compounds (HCFCs) that have a longer phase-out schedule.

substitutes,[44] including hydrogen peroxide, chlorine dioxide (produced from sodium chlorate), oxygen, and ozone.

Chlorine's use as a disinfectant in tap water may be reduced as a result of rising concern over chlorine byproducts, especially trihalomethanes, and concern that chlorine-treated water may not eradicate certain pathogens. According to industry observer estimates, the percentage of municipality facilities that use chlorine as a disinfectant (about 87 percent in late 1997) will decline sharply in the foreseeable future as chlorine is increasingly replaced by substitutes.[45] The cost of phasing out all or almost all chlorine to the U.S. and Canadian economies was estimated in 1994 to amount to $102 billion plus $67 billion in capital changeover costs. However, other sources, such as Greenpeace, estimate a much lower cost.[46]

In contrast to chlorine, environmental considerations have not been cited as substantially reducing demand for chlorine's co-product, caustic soda. In fact, one of caustic soda's uses is to neutralize acid rain. However, because caustic soda and chlorine are co-products, the relative cost of the caustic soda co-product would increase if demand for chlorine declined.

Environmentally, the natural soda ash production process, like other mining production processes, has come under increasing scrutiny and regulation. Recent concerns have focused on the impact of the soda production process on global-warming and on wildlife. Other environmental concerns relate to air particulates and to the discharge of methane and some ammonia when underground mines are flushed with air.[47] However, the soda ash industry has not seen the kind of intense environmental and health concerns that have affected U.S. producers of chlorine and downstream products.

Substitutability of Soda Ash and Caustic Soda

Given the chemical similarity between soda ash and caustic soda, the two large-volume alkali chemicals compete; however, because soda ash is generally sold as a dry mix and caustic soda is generally sold as a solution, either one or the other chemical is preferred by the end user.[48] For example, in glass manufacture where a dry mix is desirable, soda ash is preferred. Although some caustic soda is sold as dry flakes, these flakes are relatively expensive and

[44] *Chemical Marketing Reporter*, Sept. 16, 1996, p. SR7.

[45] *Chemical Market Reporter*, Oct. 13, 1997, pp. SR5-SR6.

[46] *Chemical and Engineering News*, Nov. 21, 1994, p. 18.

[47] U.S. Geological Survey official, interview by USITC staff, July 2, 1998.

[48] Although caustic soda and soda ash are chemically similar and can be used in many similar applications, most consumers of these two chemicals do not switch from one chemical to another in response to changing market conditions, e.g., prices. The amount of caustic soda and soda ash substituted for each other as a result of changing market conditions has been estimated to range between 300,000-500,000 tons, representing only about 2-3 percent of combined annual caustic soda and soda ash consumption. A contributing factor to the relative lack of substitutability between soda ash and caustic soda is the costly retrofitting required to switch between the two products. Some producers of pulp and paper and water treatment chemicals, however, have developed the ability to switch alkali as market conditions change. Alternatively, soda ash can be converted to caustic soda using a chemical process that does not produce chlorine (the lime soda process); however, this process currently accounts for only a small percentage of caustic soda production.

often too coarse to be useful. Soda ash is often preferred where price is the chief consideration and where there is no technical advantage in using caustic soda.[49]

However, other than in glass manufacture, caustic soda is often more convenient to use because it is usually dissolved in water, which is easier to store and transport than a solid. Also, because caustic soda production is more widely dispersed geographically, freight costs are generally lower for caustic soda.[50] Caustic soda also is the preferred alkali for many applications because pound for pound it is more alkaline than soda ash, and therefore it is a more efficient neutralizing agent.

Pricing and Unit Values

As discussed in earlier sections, the prices of the co-products chlorine and caustic soda tend to fluctuate sharply in response to changing market conditions. Figure 6 shows 1991-96 and first quarter 1997 prices for chlorine and caustic soda in the Gulf States and the combined *electrochemical unit (ECU)* price.[51] During 1991 and the first half of 1992, the price for the chlorine component remained at less than about $50 per short ton.[52] After the first half of 1992, the chlorine price rose steadily until it reached about $160 per short ton at the beginning of 1994, after which the chlorine price remained fairly steady until late 1996. In the last quarter of 1996, the chlorine price began to rise again, reaching about $200 per short ton in the first quarter of 1997. This rise likely reflected increased chlorine consumption attributable largely to increased PVC use. During 1992-96, the price of caustic soda and the price of chlorine were frequently in an inverse relationship; for example, in the first half of 1992, when the price of chlorine was weak, the price of caustic soda was relatively strong (over about $200 per short ton).[53]

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[49] Because of the high price volatility of caustic soda, there have been occasions when caustic soda prices, in units of alkali strength, were equal to or even lower than those of soda ash. For example, according to an industry observer, caustic soda prices have fallen to the point where, as of June 1997, they have become relatively inexpensive compared to soda ash prices. The low prices for caustic soda were triggered by excess caustic soda production brought on by strong demand for the co-product chlorine. (Roger Shamel, *The Role of Soda Ash in the Chloralkali Family of Chemicals*, presented at the First International Soda Ash Conference, Rock Springs, WY, June 11, 1997.)

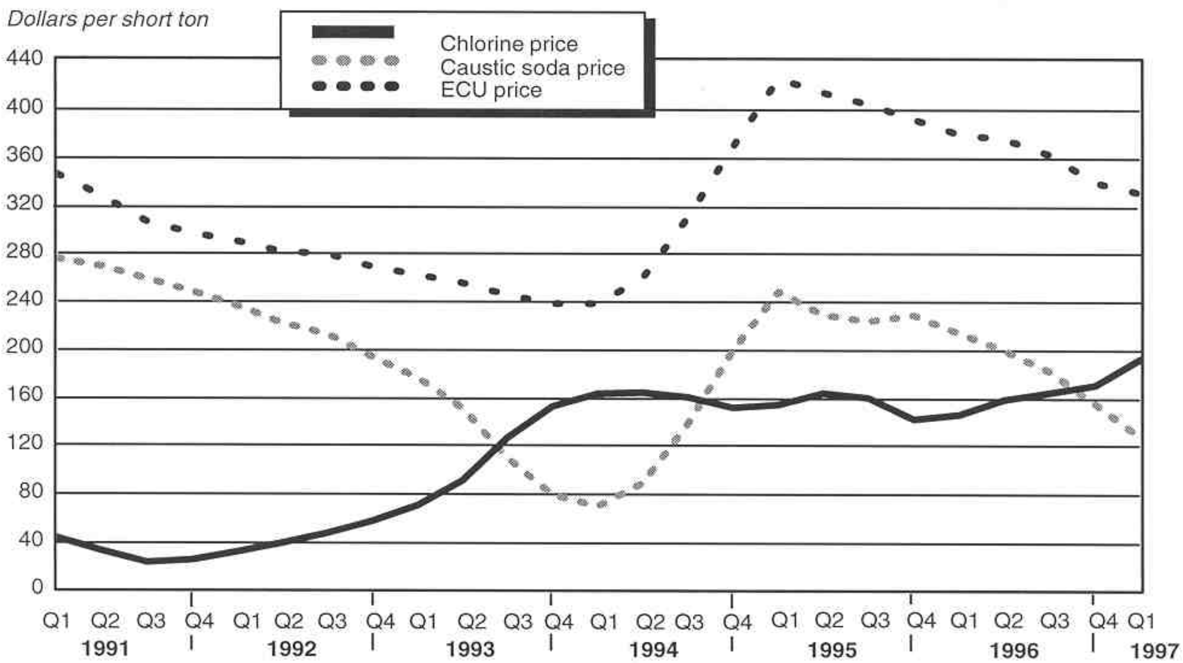
[50] *Chemical Market Reporter*, Apr. 28, 1997, p. 22.

[51] The ECU price represents the price of one ton of chlorine and 1.1 ton of co-product caustic soda. The 1:1.1 ratio corresponds to the relative quantities of chlorine and caustic soda produced in the electrolysis of aqueous sodium chloride (brine). The ECU price provides a useful measure of determining how the combined price of chlorine and caustic soda produced by the electrolysis of brine compares to the cost of production, which is largely the electricity required for the electrolysis of the brine.

[52] According to an industry source, in late 1991 some chlorine was given away to move the product.

[53] This inverse relationship was reflected in the fact that during 1992-96 the ECU price fluctuated less in percentage terms than either the chlorine or caustic soda price (figure 6).

Figure 6
Quarterly chlorine, caustic soda, and ECU prices[1] per short ton (U.S. Gulf Coast), 1991-96 and first quarter 1997



[1] The ECU price is the price of one ton of chlorine and 1.1 tons of caustic soda. The 1:1.1 ratio corresponds to the ratio of chlorine to caustic soda generated during the electrolysis of brine.

Source: Compiled from data provided by Probe Economics. Printed with permission of Probe Economics.

The willingness of producers to sell chlorine or caustic soda at lower prices during a period of low demand for either product reflects the high expense associated with the storage of the co-product produced in excess. Because of this expense, chlorine/caustic soda producers are often reluctant to store these products in anticipation of selling at higher prices in the future. However, when chlorine is in excess, producers can reduce their storage and maintenance costs by converting the chlorine to downstream products such as EDC, VCM, and PVC.

The average unit value of soda ash during 1992-96 in dollars per metric ton as compiled by the U.S. Geological Survey declined by 13 percent during 1992-94 from $89.21 to $77.65; it then rose in 1995 and 1996 to $82.12 and $91.05, respectively.[54] The average unit value then declined to $85.15 in 1997.[55] The net result was that in 1996 the average unit value for soda ash was only slightly higher (by 2 percent) than in 1992, and in 1997 the average unit

[54] The unit value for soda ash is not actually a "price" but rather corresponds to the "value of the combined revenue of California and Wyoming bulk dense soda ash sold on an f.o.b. plant basis at list, spot, or discount prices, on long-term contracts, and for export, divided by the quantity of soda ash sold." U.S. Geological Survey, *Soda Ash, Annual Review-1997.*

[55] U.S. Geological Survey, *Soda Ash, Annual Review-1996*; U.S. Geological Survey, *Mineral Industry Surveys: Soda Ash and Sodium Sulfate in January 1998*.

value for soda ash had declined relative to 1992 by 5 percent. Factors that explain why unit values for soda ash did not increase significantly during 1992-96 include increased use of plastics and aluminum in the container market and increased glass recycling. Both of these factors, which reduced growth in demand for soda ash in its principal end-use application (glass production), may have contributed to some oversupply of soda ash in the U.S. market.

According to an industry source, typical caustic soda contracts for merchant deliveries last 3 to 6 years but allow for pricing mechanisms to reflect market conditions. The spot market, however, remains important because it enables producers to gauge prices in the market. This knowledge can be useful when negotiating new contracts. The spot market is also a convenient outlet for excess caustic soda that has not been contracted out.[56] For soda ash, a typical contract for large-volume users is a single year contract with escalating and de-escalating clauses relative to the base price.[57] As most chlorine is used internally, information on contractual arrangements for merchant chlorine is not readily available.

Chlorine and Caustic Soda

U.S. shipments of chlorine and caustic soda amounted to about $948 million and $1.86 billion in 1996, respectively. The combined figure accounted for about 68 percent of total chloralkali shipments (including natural soda ash) in that year.[58]

In table 4, quantity data on U.S. production, consumption, percentage of consumption imported, and percent of production exported of chlorine and caustic soda are shown for 1992-96.[59] According to the Chlorine Institute, U.S. production of chlorine rose by 13 percent during 1992-96, from 10.6 million metric tons to 11.9 million metric tons. Because imports exceeded exports during this time, U.S. apparent consumption exceeded U.S. production.

As might be expected because chlorine and caustic soda are chemical co-products, U.S. production of caustic soda, produced electrolytically, which accounts for almost all caustic soda production, rose in line with chlorine during this period, also increasing by about 13 percent, from 11.2 million metric tons in 1992 to 12.6 million metric tons in 1996 (table 4). U.S. consumption of caustic soda remained less than U.S. production, because exports exceeded imports throughout 1992-96 by a significant amount.[60] During 1992-96, U.S. consumption of chlorine increased steadily, rising by 14 percent. In contrast, U.S. consumption of caustic soda rose during 1992-96 by only 6 percent. U.S. caustic soda consumption rose during 1992-94 by 12 percent but then declined in 1995 by 5 percent and remained essentially flat in 1996. The lag in U.S. consumption of caustic soda relative to chlorine is likely attributable to the fact that there are no major uses for caustic soda that exhibited the strong growth pattern characterized by PVC.

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[56] U.S. industry official, interview by USITC staff, Apr. 16, 1996.

[57] Ibid.

[58] Bureau of the Census, Current Industrial Reports, *Annual Report on Inorganic Chemicals-1996*; U.S. Geological Survey, *Soda Ash Annual Review-1996*.

[59] U.S. apparent consumption was calculated from production data by subtracting exports and adding imports.

[60] During a period when chlorine demand is high relative to caustic soda, the industry may dispose of excess caustic soda through exports.

Table 4
Chlorine and caustic soda: U.S. production, exports, imports, apparent consumption, imports to consumption ratio, and exports to production ratio, 1992-96

(Thousand metric tons)

Item	1992	1993	1994	1995	1996
Chlorine:					
Production	10,574	10,871	11,442	11,784	11,946
Exports[1]	31	37	27	24	17
Imports[1]	250	293	357	360	380
Consumption	10,793	11,127	11,772	12,120	12,309
Imports to consumption ratio (percent)	2	3	3	3	3
Exports to production ratio (percent)	([2])	([2])	([2])	([2])	([2])
Caustic soda:					
Production	11,189	11,452	12,059	12,418	12,571
Exports[3]	1,150	877	771	1,676	1,868
Imports[3]	516	455	486	488	513
Consumption	10,555	11,030	11,774	11,230	11,216
Imports to consumption ratio (percent)	5	4	4	4	5
Exports to production ratio (percent)	10	8	6	14	15

[1] In 1997, U.S. exports and imports of chlorine amounted to 24,000 metric tons and 411,000 metric tons, respectively.
[2] Less than 0.5 percent.
[3] In 1997, U.S. exports and imports of caustic soda amounted to 1.35 million metric tons and 499,000 metric tons, respectively.

Source: Trade data compiled by the U.S. Department of Commerce; production data provided by the Chlorine Institute.

Soda Ash

U.S. production of soda ash amounted to about $926 million in 1996. This figure accounted for about 22 percent of total chloralkali shipments in that year.[61] Quantity data on U.S. production, exports, imports, and apparent consumption of soda ash compiled by the DOC and U.S. Geological Survey for the period 1992-96 are shown in table 5.

During 1992-96, U.S. production of soda ash rose irregularly from 9.4 to 10.2 million metric tons, an overall increase of 8 percent. During this period, U.S. exports of soda ash rose by 30 percent, increasing from 3.0 million to 3.8 million metric tons, and the portion of U.S. production that was exported rose from 32 to 38 percent. In contrast to the relatively steady and significant growth in exports, U.S. apparent consumption of soda ash during 1992-96 experienced a net growth of only two percent. Factors that limited growth of U.S. soda ash

[61] U.S. Geological Survey, *Soda Ash Annual Review-1996*; Bureau of the Census, Current Industrial Reports, *Annual Report on Inorganic Chemicals-1996*. The assumption is made that the production value for soda ash equals the shipment value for that product.

markets[62] during this period included increased glass container recycling and increased substitution of other materials for glass.

Table 5
Soda ash: U.S. production, exports, imports, apparent consumption, percentage production exported and percentage consumption imported, 1992-96

(*Thousand metric tons*)

Item	1992	1993	1994	1995	1996
Production	9,380	8,960	9,320	10,100	10,200
Exports[1]	2,960	2,800	3,230	3,570	3,840
Imports[1]	72	89	79	83	107
Apparent consumption[2]	6,360	6,350	6,240	6,510	6,470
Percentage production exported	32	31	35	35	38
Percentage consumption imported	1	1	1	1	2

[1] In 1997, U.S. exports and imports of soda ash amounted to 4.2 million metric tons and 101,000 metric tons, respectively.
[2] Includes changes in inventories.

Source: Trade data compiled by the U.S. Department of Commerce and modified by the U.S. Geological Survey; production and apparent consumption data provided by the U.S. Geological Survey.

U.S. TRADE

Overview

Reflecting the competitive advantages the United States enjoys in the chloralkali sector, the United States exports much more chloralkali (especially soda ash and caustic soda) than it imports. During 1992-97, the ratio of exports to imports for the chloralkali chemicals ranged, by value, between four and five to one.

Table 6 shows U.S. exports, imports, and the merchandise trade balance for the chloralkali chemicals, in terms of value, with leading countries and regional associations during 1992-97. During 1992-94, U.S. exports of the chloralkali chemicals declined in value from $803 million to $594 million, but during 1994-96 these exports rebounded to $967 million. In 1997, these exports declined to $824 million. The volatility of the volume and unit value of caustic soda appears to be the principal factor accounting for these sharp fluctuations. A roughly similar trend occurred for U.S. imports of the chloralkali chemicals, which declined from $170 million in 1992 to $125 million in 1993 but then increased to $210 million in 1995. However, in 1996 and 1997, these imports declined to $188 million and to $184 million, respectively.

[62] Of the 6.5 million metric tons of soda ash consumed in the United States during 1996, according to the U.S. Geological Survey, about 48 percent was used in glass manufacture, 27 percent in the manufacture of chemicals, and 12 percent in the manufacture of soaps and detergents.

Table 6
Chloralkali chemicals: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1992-97

(1,000 dollars)

Item	1992	1993	1994	1995	1996	1997
U.S. exports of domestic merchandise:						
Canada	92,162	83,721	81,686	122,139	145,332	126,365
Mexico	44,725	35,881	41,955	48,577	59,574	71,156
Japan	42,418	58,053	54,575	50,377	52,822	61,096
Indonesia	31,567	31,913	38,209	46,800	61,030	57,874
Korea	40,637	38,855	50,319	42,936	49,575	49,635
Brazil	24,569	12,480	24,413	39,625	50,008	45,289
Venezuela	63,080	44,731	39,777	63,642	64,246	43,552
Thailand	21,336	13,991	25,978	36,283	44,911	35,677
Taiwan	21,695	19,691	28,995	39,894	30,020	31,902
Belgium	31,364	24,563	21,983	10,623	15,999	17,054
All other	389,668	234,195	186,073	397,718	393,917	284,861
Total	803,221	598,073	593,963	898,614	967,435	824,460
EU-15	95,762	62,882	34,227	35,491	47,814	48,731
OPEC	97,135	82,435	83,391	120,755	141,773	116,728
Latin America	295,727	184,342	199,321	343,743	355,444	287,354
CBERA	72,411	31,930	29,936	82,347	79,305	39,079
Asian Pacific Rim	285,499	239,741	247,559	357,160	360,612	321,986
ASEAN	77,553	69,978	86,746	117,546	139,914	135,308
Central and Eastern Europe	13,785	9,141	8,978	4,060	5,076	3,301
U.S. imports for consumption:						
Canada	85,737	77,172	85,800	110,784	110,385	114,652
Mexico	1,612	2,171	5,292	6,630	6,556	8,082
Japan	9,586	4,006	3,991	8,937	1,630	554
Indonesia	0	0	0	0	0	7
Korea	134	0	0	0	20	56
Brazil	5,916	3,237	775	2,547	2,822	1,885
Venezuela	0	0	10	17	1,087	1,202
Thailand	0	0	0	0	0	0
Taiwan	125	120	11	0	29	0
Belgium	7,693	3,606	9,370	13,908	19,202	11,724
All other	58,855	34,975	43,717	67,215	46,578	45,583
Total	169,658	125,287	148,967	210,038	188,308	183,746
EU-15	57,896	32,956	45,054	62,609	62,579	51,961
OPEC	4,877	1,164	10	3,786	2,570	5,131
Latin America	7,601	5,430	6,926	9,687	11,350	11,597
CBERA	0	0	286	342	0	4
Asian Pacific Rim	10,265	4,393	4,352	9,156	1,959	858
ASEAN	0	0	0	0	4	30
Central and Eastern Europe	174	819	5,933	273	433	395
U.S. merchandise trade balance:						
Canada	6,425	6,549	-4,114	11,356	34,947	11,713
Mexico	43,114	33,709	36,662	41,947	53,018	63,074
Japan	32,831	54,047	50,584	41,440	51,192	60,542
Indonesia	31,567	31,913	38,209	46,800	61,030	57,867
Korea	40,503	38,855	50,319	42,936	49,555	49,578
Brazil	18,653	9,242	23,638	37,078	47,186	43,404
Venezuela	63,080	44,731	39,767	63,625	63,160	42,350
Thailand	21,336	13,991	25,978	36,283	44,911	35,677
Taiwan	21,570	19,571	28,984	39,894	29,991	31,902
Belgium	23,671	20,957	12,613	-3,286	-3,202	5,330
All other	330,813	199,221	142,355	330,503	347,339	239,277
Total	633,563	472,786	444,997	688,576	779,127	640,715
EU-15	37,867	29,925	-10,827	-27,118	-14,765	-3,231
OPEC	92,258	81,271	83,381	116,969	139,203	111,597
Latin America	288,126	178,911	192,394	334,056	344,095	275,757
CBERA	72,411	31,930	29,650	82,005	79,305	39,075
Asian Pacific Rim	275,234	235,347	243,207	348,004	358,653	321,128
ASEAN	77,553	69,978	86,746	117,546	139,910	135,278
Central and Eastern Europe	13,611	8,323	3,045	3,786	4,642	2,906

Note.—Because of rounding, figures may not add to totals shown. The countries shown are those with the largest total U.S. trade (U.S. imports plus exports) in these products in 1997.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Primarily because of a decline in both the unit value and the volume of exports of caustic soda in aqueous solution[63] — by 31 percent and 34 percent, respectively— and a 14 percent decline in the average unit value for soda ash, the U.S. merchandise surplus for the chloralkali chemicals declined from $634 million in 1992 to $445 million in 1994. During 1994-96, primarily because of a sharp increase in the quantity of U.S. exports of caustic soda in aqueous solution and of soda ash — by 161 percent and 20 percent, respectively— and a concomitant rise (19 percent) in the unit value for aqueous caustic soda, the U.S. merchandise surplus for the chloralkali chemicals rose from $445 million to $779 million. During 1996-97, as a result of a steep drop in both the volume and the average unit value of caustic soda exports in aqueous solution (by 28 percent in volume and by 22 percent in unit value), the U.S. merchandise surplus for the chloralkali chemicals declined from $779 million to $641 million.

U.S. Imports

Principal Suppliers and Import Levels

During 1992-97, caustic soda was the leading chloralkali chemical imported, accounting for 40 percent or more of the value of chloralkali imports. Chlorine, caustic potash, soda ash, and sodium bicarbonate accounted for the bulk of the remainder.

U.S. imports of chlorine from Canada, the dominant foreign supplier, were small, amounting to no more than 3 percent of U.S. consumption during 1992-96. In 1997, U.S. imports of chlorine amounted to 411 million kilograms, valued at $61 million (table C-1). It is believed that these imports were shipped across the border for applications characteristic of the northern United States such as pulp and paper bleaching. U.S. imports of chlorine during 1992-97 from countries other than Canada and Mexico were negligible, probably because of the expense associated with shipping chlorine over long distances.

During 1992-97, U.S. imports of caustic soda in aqueous solution, the dominant form of caustic soda traded, were relatively stable in terms of quantity, varying between 440 million and 499 million kilograms of contained weight of dry equivalent caustic soda, or a range of 13 percent (table C-2). In contrast, the total customs value of these imports fluctuated by a much larger margin (83 percent), primarily as a result of sharp fluctuations (by 70 percent) in the average unit values for this product. (As discussed in the **Pricing and Unit Values** section, caustic soda prices are highly volatile.)

Canada accounted for at least 40 percent of U.S. imports of caustic soda in aqueous solution, in terms of quantity, during 1992-97. Caustic soda imports from Canada may have been used in applications common to the northern part of the United States, such as pulp and paper processing. Other significant suppliers of caustic soda to the United States during the period

[63] Caustic soda is shipped in both aqueous and solid forms. However, the aqueous form predominates. For example, in 1997, caustic soda in aqueous solution accounted for 91 percent of total U.S. caustic soda exports, valued at $227 million.

covered by this summary included Belgium, France, Saudi Arabia, Germany, Brazil, and the United Kingdom.

U.S. imports of other alkalis, including caustic potash, soda ash, sodium bicarbonate, potassium carbonate, and potassium bicarbonate, did not exceed $20 million per commodity on an annual basis during 1992-97. Because of the competitive strengths of the U.S. soda ash industry, imports of soda ash (101,000 metric tons in 1997) amounted to less than two percent of domestic consumption.

U.S. imports of caustic potash did not exceed 50,000 metric tons per year during 1992-94; however, they surged to 208,000 metric tons in 1995 before falling back to 27,000 metric tons in 1996 and 34,000 metric tons in 1997 (table C-3).[64] Imports from Belarus and Russia accounted for almost all of the increase in 1995. Caustic potash is used to produce potassium carbonate, a chemical that is finding increased use in the production of video glass.

U.S. Trade Measures and U.S. Government Trade-Related Investigations

Table 7 shows the column 1 rates of duty as of January 1, 1998, for imports of chlorine, sodium hydroxide (solid and in aqueous solution), potassium hydroxide, soda ash (sodium carbonate), sodium bicarbonate, and potassium carbonate and bicarbonate under the *Harmonized Tariff Schedule* (*HTS*) *of the United States*.[65] This table includes duties assessed on imports from countries that have normal trade relations status, as well as rates of duty for countries qualifying for special tariff preferences. U.S. duty rates for the products in this grouping are either zero or relatively low; the highest duty rate, for potassium carbonate, is only 1.9 percent ad valorem. During the Uruguay Round, no concessions were made by the United States for the dutiable HTS subheadings covered by this summary.[66] No significant U.S. nontariff barriers for the chloralkali industry have been reported to Commission staff.

During 1992-96, there was only one U.S. Government trade-related investigation conducted by the U.S. International Trade Commission (USITC) and the DOC dealing with the chloralkali chemicals covered by this summary. On January 2, 1992, a petition was filed with the USITC and the DOC under the U.S. antidumping law (19 U.S.C. 1673 et seq.) on behalf of LinChem, Inc., alleging that imports of potassium hydroxide (caustic potash) from Canada, Italy, and the United Kingdom were being sold in the United States at less than fair value.[67] On February 18, 1992, the USITC made a negative determination in the preliminary phase of its investigation, finding that there is no reasonable indication that an

[64] Analysis of trade data for caustic potash may be complicated by the fact that the product is imported in both solid and solution form.

[65] See appendix A for tariff and trade agreement terms.

[66] Presidential Proclamation 6763, "To Implement the Trade Agreements Resulting From the Uruguay Round of Multilateral Trade Negotiations, and for Other Purposes," Dec. 23, 1994.

[67] 57 F.R. 924-925.

Table 7
Chlorine and certain alkali products: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1998; U.S. exports, 1997; and U.S. imports, 1997

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1998		U.S. exports, 1997	U.S. imports, 1997
		General	Special[1]		
				)))))) *Million dollars*))))))	
2801.10	Chlorine	Free		8.6	61.1
2815.11	Sodium hydroxide, solid	Free		19.3	14.6
2815.12	Sodium hydroxide, in aqueous solution	Free		208.0	73.6
2815.20	Potassium hydroxide	Free		28.7	10.3
2836.20	Sodium carbonate	1.2%	Free (A*[2],CA,E,IL,J,MX)	527.3	12.7
2836.30	Sodium bicarbonate	Free		23.5	9.7
2836.40.10	Potassium carbonate	1.9%	Free (A*[2],CA,E,IL,J,MX)	([3])	0.8
2836.40.20	Potassium bicarbonate	1.3%	Free (A*[2],CA,E,IL,J,MX)	([3])	0.9

[1] Programs under which special tariff treatment may be provided and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn are as follows: Generalized System of Preferences (A or A*); North American Free Trade Agreement, eligible goods of Canada (CA); Caribbean Basin Economic Recovery Act (E); United States-Israel Free-Trade Agreement (IL); the Andean Trade Preference Act (J); and the North American Free Trade Agreement, eligible goods of Mexico (MX).

[2] India is currently (1998) ineligible to receive duty concessions under the Generalized System of Preferences for this HTS subheading.

[3] U.S. exports of potassium carbonate (dipotassium carbonate) and potassium bicarbonate are not reported separately. The combined export value for these products in 1997 amounted to $9.0 million.

Source: USITC, Harmonized Tariff Schedule of the United States, 1998. Exports and imports compiled from official statistics of the U.S. Department of Commerce.

industry in the United States is materially injured or threatened with material injury, or that the establishment of an industry in the United States is materially retarded, by reason of imports of potassium hydroxide from Canada, Italy, and the United Kingdom.[68] As a result, both the USITC and the DOC terminated their respective investigations and no antidumping order was issued.

U.S. Exports

Principal Markets and Export Levels

Because of certain advantages discussed earlier, the United States has been a net exporter of products of the chloralkali industry, especially soda ash and caustic soda. In terms of value, exports of soda ash ($527 million) and caustic soda ($227 million) accounted for 64 percent and 28 percent of total chloralkali exports, respectively, in 1997. U.S. chloralkali exports were driven by worldwide demand for intermediates for use in the manufacture of key downstream products such as aluminum and glass. According to industry sources, because of growth in overseas capacity, U.S. chloralkali exporters will likely face increased competition both from foreign exporters, such as chloralkali producers in the Persian Gulf, and from local chloralkali producers.

Foreign chloralkali production expansion has already affected U.S. exporters. China, once a major importer of soda ash, has become a net exporter.[69] In the 1980s, before it expanded capacity, China was the largest purchaser of soda ash from the United States. The volume of soda ash exports from China is currently relatively modest compared to U.S. exports; however, China, which, according to a trade journal, has been receiving government support to expand soda ash exports and to reduce imports, has the potential to become a world-class exporter.[70]

Soda ash

To maximize its natural resources advantage, U.S. exporters joined to form an export trading company in 1983. The company, American Natural Soda Ash Corp. (ANSAC), was formed under the Webb-Pomerene Act, legislation that enables U.S. companies, under certain conditions, to cooperate in exporting without facing anti-trust charges.[71] ANSAC is able to use economies of scale to maximize efficiency and minimize costs. Industry sources believe that ANSAC has significantly reduced distribution costs and wasteful duplication and is a major factor accounting for the rise in U.S. exports. For example, ANSAC ships soda ash

[68] 57 F.R. 6622-6623, and U.S. International Trade Commission, *Potassium Hydroxide from Canada, Italy, and the United Kingdom*, investigations Nos. 731-TA-542 (preliminary), 731-TA-543 (preliminary), and 731-TA-544 (preliminary), Publication 2482, February 1992.

[69] Charles Raleigh and Peter Harben, *Soda Ash Goes Global for Growth*, First International Soda Ash Conference, Rock Springs, WY, June 11, 1997.

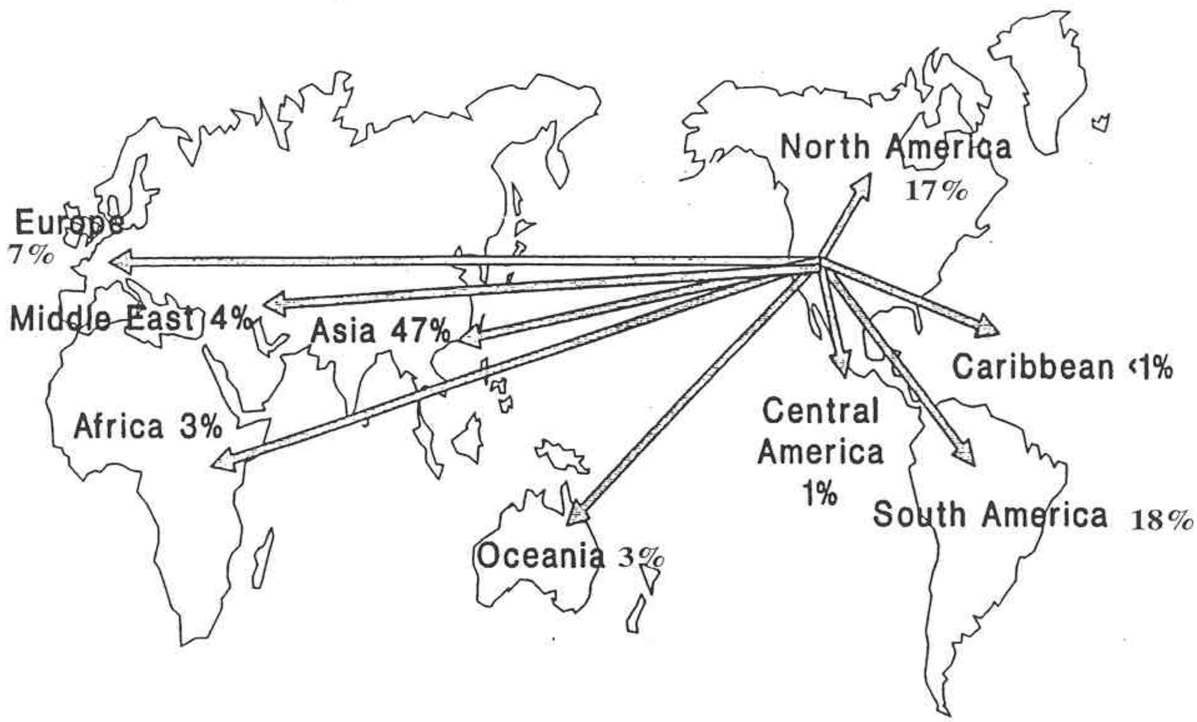
[70] *Chemical Week*, Oct 28, 1998; p. 37 and following.

[71] *Industrial Minerals*, April 1986, pp. 46-49.

from Wyoming in rail cars that are dedicated only to soda ash use, and as a large volume shipper, ANSAC can negotiate lower freight rates. However, not all U.S. soda ash exports are shipped via ANSAC.

During 1992-97, the United States exported soda ash to over 70 countries. Figure 7 shows the regional distribution of U.S. soda ash exports in 1997. In that year, most soda ash exports went to Asia, (47 percent, not including the Middle East), South America (18 percent) and North America (17 percent). Some of the larger markets for U.S. soda ash exports include Mexico, Japan, Indonesia, South Korea, Canada, Thailand, Taiwan, and Brazil.

Figure 7
Regional distribution of U.S. soda ash exports, 1997



Source: U.S. Geological Survey; data compiled by the U.S. Department of Commerce.

During 1992-97, U.S. exports of soda ash increased from 2.95 million to 4.03 million metric tons (valued at $527 million), or by 1.08 million metric tons (table C-4).[72] U.S. exports of soda ash increased because of growing worldwide demand for soda ash, especially in the Far East, and other factors, such as the closure of some foreign soda ash plants. Most of the increase in U.S. exports of soda ash during 1992-97 was accounted for by increased exports to Mexico (up by 306,000 metric tons); Indonesia (up by 175,000 metric tons); Japan (up by 173,000 metric tons); Saudi Arabia (up by 123,000 metric tons); Canada (up by 113,000 metric tons); Brazil (up by 101,000 metric tons); and Thailand (up by 99,000 metric tons). These countries are significant consumers of soda ash. According to industry observers, the impact of the recent Asian economic crisis has significantly reduced the level of U.S. exports of soda ash to the Far East.[73]

During 1992-97, U.S. soda ash exports to some markets increased only modestly, fluctuated irregularly, or declined. For example, U.S. soda ash exports to the Netherlands, which amounted to 143,000 metric tons in 1992, were negligible during 1994-97. U.S. exports of soda ash to Belgium and Spain also declined steeply during 1992-97.

During 1992-95, the average unit value of U.S. soda ash exports declined by 15 percent from 14.7 cents per kilogram to 12.5 cents per kilogram. Although the average unit value for U.S. soda ash exports increased in 1996 to 13.2 cents per kilogram, that figure was still well below the average unit value for soda ash reported in 1992. In 1997, the average unit value for U.S. soda ash exports declined slightly to 13.1 cents per kilogram. The decline in average unit values in 1997 may be attributable to domestic soda ash overcapacity.

Caustic soda

Figure 8 illustrates the regional trade patterns for suppliers and consumers of caustic soda. According to the figure, the United States accounted for an estimated 46 percent of worldwide caustic soda exports.

During 1992-94, U.S. exports of caustic soda in aqueous solution, the principal form traded, declined in terms of volume from 1.06 million metric tons to 704,000 metric tons (34 percent) on a dry weight basis and also in terms of average unit value from 24.5 to 17.0 cents per kilogram (31 percent) (table C-5). As a result of these two factors, the value of U.S. exports of caustic soda in aqueous solution declined by 54 percent during 1992-94, from $261 million to $119 million. According to an industry source, U.S. exports of caustic soda declined both in terms of quantity and unit value during 1992-94, largely because of sluggish worldwide demand for alumina, a chemical used to make aluminum metal. Alumina is produced by the leaching of the mineral bauxite with caustic soda, and caustic soda used for alumina

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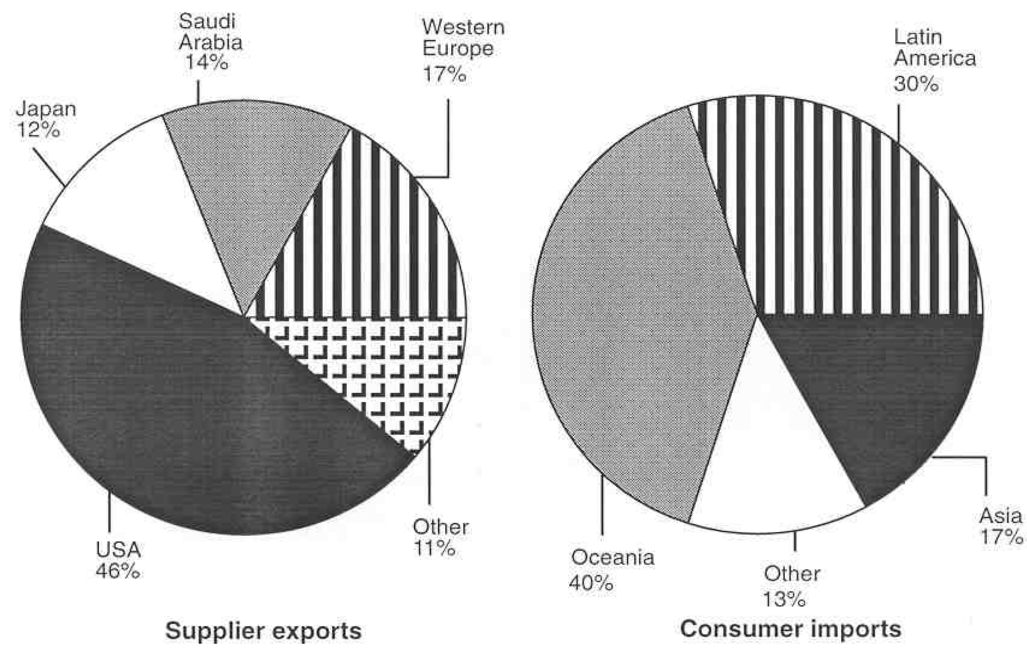
[72] The U.S. Geological Survey has revised some of the data compiled by the U.S. Department of Commerce. For example, in 1997 the U.S. Geological Survey reported that total U.S. exports of soda ash amounted to 4.19 million metric tons valued at $547 million (*Mineral Industry Surveys; Soda Ash: 1997 Annual*.)

[73] For example, in March 1998, U.S. soda ash production declined by 9 percent relative to the previous month. Industry observers attribute this decline to reduced exports to Asia caused by the Asian economic crisis (*Chemical Market Reporter*, Jun 8, 1998, pp. 5, 29).

manufacture is believed to constitute the largest end use for caustic soda exports. The decline in the unit value of caustic soda exports during 1992-94 tracked the domestic price of caustic soda, which also decreased during that period (see **Pricing and Unit Values** section).

Figure 8
Trade in caustic soda by region, 1995



Source: James Usher, Presented at the Chloralkali Industry Update and Forecast Conference, May 29-30, 1996. Reprinted with permission of James Usher.

During 1994-96, perhaps because of an improvement in the alumina export market, caustic soda exports in aqueous solution increased steadily in terms of volume, more than doubling to 1.84 million metric tons and increasing irregularly in unit value from 17.0 cents per kilogram in 1994 to 20.3 cents per kilogram in 1996. U.S. caustic soda exports increased most rapidly to Australia, Jamaica, Suriname, and Canada. All of these countries are known to have alumina capacity. Despite the fact that Canada is an alumina and aluminum producer, it is likely the largest U.S. export market for caustic soda used in non-alumina related applications, e.g., pulp and paper manufacture.

U.S. exports of caustic soda in aqueous solution, in terms of dry weight equivalent, declined by 28 percent in volume from 1.84 million metric tons in 1996 to 1.32 million metric tons in 1997 (table C-5). Most of this decline was accounted for by reduced shipments to Australia and Jamaica. According to industry observers, the decline of U.S. exports of caustic soda to Australia and Jamaica in 1997 are in part related to increased competition from lower-priced foreign producers.

During 1996-97, the average unit value for exports of caustic soda in aqueous solution declined by 22 percent, falling from 20.3 cents per kilogram to 15.8 cents per kilogram (table C-5). The unit value for caustic soda in 1997 was lower than any other year covered in this summary. The decline occurred even though, according to a trade journal, demand for caustic soda picked up by the middle of the year after starting slowly.[74]

Caustic potash

During 1992-97, U.S. exports of caustic potash, most of which went to Canada, Japan, Mexico, and Belgium, ranged in quantity between 55 million and 95 million kilograms and in value between $21 million and $40 million (table C-6). Caustic potash's average unit export values declined during 1992-97, but without exhibiting the high volatility of the unit values of caustic soda, a chemical with which it shares many chemical and commercial characteristics. For example, during 1992-94 caustic potash's average unit values declined far less sharply than those of aqueous caustic soda (11 percent for caustic potash compared to 31 percent for aqueous caustic soda). During 1994-97, average unit values for caustic potash continued to fall slightly (by 6 percent) in a relatively smooth manner. The decline in average unit values during 1992-97 may be related to the increase in domestic production capacity for this chemical (see discussion in **U.S. Industry Profile**).

Chlorine

As noted previously, because of the expense of handling and transporting elemental chlorine, U.S. exports of chlorine were relatively small, amounting to 17,430 metric tons, valued at $7.9 million in 1996. In contrast to the limited market for elemental chlorine, exports of the downstream products, especially those used to make PVC, as well as PVC itself, were significant, amounting to about 18 percent of total U.S. chlorine production in early 1995.[75] The following tabulation illustrates the estimated uneven growth of U.S. net exports of two downstream products of chlorine that are precursors of PVC, ethylene dichloride (EDC) and vinyl chloride monomer (VCM), in units of thousands of short tons, chlorine content:[76]

Year	EDC	VCM	Total
1980	212	208	420
1986	209	423	632
1987	342	240	582
1992	564	431	995
1994	697	590	1,287
1995	641	575	1,216
1996	817	616	1,433
1997	525	704	1,229

[74] *Chemical and Engineering News*, Oct. 20, 1997, p. 19.

[75] Mannsville Chemical Products Corp., *Chemical Products Synopsis*, May 1995.

[76] Estimates provided by Sylvie Berthiaume, SRI International, publisher of the *Chemical Economics Handbook*, June 1998. The data were provided with the permission of the publisher.

Foreign Trade Measures

Tariff measures

Duties levied in recent years by selected trading partners on exports from the United States are shown in the tabulation in the following tabulation.[77] These duties do not include other taxes such as the value added tax (VAT).

Country	HS subheading[1]						
	2801.10	2815.11	2815.12	2815.20	2836.20	2836.30	2836.40
Argentina	8%	8%	8%	6%	3%[(2)]	10%	10%
Australia	Free	Free	Free	Free	5%	Free	Free
Brazil	8%	8%	8%	6%	10%	10%	10%
Canada	Free	Free	Free	Free	Free	Free	Free
China	6%	14%	14%	10%	12%	10%	9%
European Union	9.4%	10.1%	10.1%	9.4%	7.3%	7.3%	6.5%
India[3]	30%	30%	30%	30%	30%	30%	30%
Jamaica	5%	5%	5%	5%	5%	5%	5%
Japan	2.7%	5.7%	5.7%	4.2%	([4])	4.2%	4.2%
South Korea	8%	8%	8%	8%	8%	8%	8%
Mexico[5]	5%	2.5%	2.5%	5%	5%	5%	([6])
Thailand	15%	20%	10%	10%	5%	10%	10%
Taiwan	Free	2.5%	2.5%	5%	8.5%	5%	5%

[1] The HS numbers included in this table represent the following products; HS 2801.10, chlorine; HS 2815.11, sodium hydroxide, solid; HS 2815.12, sodium hydroxide, in aqueous solution; HS 2815.20, potassium hydroxide; HS 2836.20, sodium carbonate; HS 2836.30, sodium bicarbonate; and HS 2836.40, potassium carbonate and potassium bicarbonate.

[2] Rate to countries outside the Mercosur countries (in addition to Argentina, Brazil, Paraguay, and Uruguay, scheduled to be staged upwards to 10 percent by 2001).

[3] Net payable duty tax and 5% surcharge included.

[4] 1.45 yen/kilogram for soda ash; 3.5 percent for other.

[5] Under NAFTA, many products exported to Mexico from the United States are undergoing staged duty reductions.

[6] The duty for U.S. exports of potassium carbonate to Mexico is 5 percent ad valorem; eligible U.S. exports of potassium bicarbonate to Mexico are free of duty.

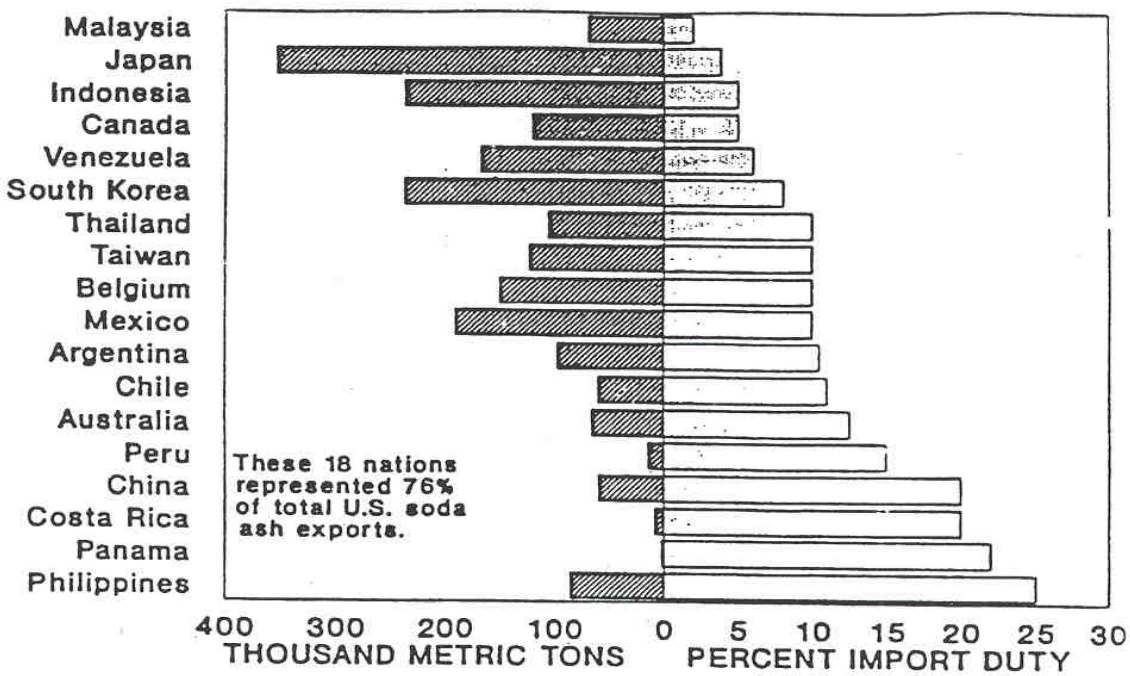
Duties ranged from free to 30 percent ad valorem (India). In general, foreign duties on imports of the chloralkali chemicals are substantially higher than duties in the United States. According to an industry observer, the high duties in India had a major impact on reducing U.S. exports to that country.[78]

[77] Duty rates provided by the Trade Information Center at the Department of Commerce and by country specialists in that agency as well as from material provided by the United Nations Conference on Trade and Development (UNCTAD) and the World Bank. The most recent duty rates available were used.

[78] During 1992-97, U.S. exports of chloralkali products to India ranged from $22,000 (1992) to $3.9 million (1996). Except for 1996, annual U.S. exports to India of these products during 1992-97 were less than $1.0 million. In contrast, U.S. exports of chloralkali products to many smaller developing countries were much larger.

The former U.S. Bureau of Mines correlated U.S. exports of soda ash with foreign import duties for 1993 (figure 9)[79] and, as would be expected, there was an inverse relationship between these two variables.

Figure 9
Soda ash: Relationship between foreign import duty and exports from the United States, 1993



Source: U.S. Bureau of Mines. Reprinted with permission of the U.S. Geological Survey.

In addition to ordinary duties, tariff barriers may arise because a country imposes special duties on a party that it rules poses a concern or has violated its trade regulations. Such a special duty has been imposed on U.S. exports of soda ash to the EU. In response to a complaint by European soda ash producers alleging that U.S. soda ash producers have been dumping soda ash in the European market, the European Commission imposed antidumping duties on U.S. producers beginning in the early 1980s that were lifted in late 1990.[80] Following the lifting of the dumping duties, U.S. exports of soda ash to Europe rose rapidly, prompting concern by the European industry. In July 1993, the European Commission of the EU began investigating a complaint by the European Chemical Industry Council alleging that U.S. exports to Europe had been dumped. On April 14, 1995, the European Commission imposed provisional antidumping duties ranging up to 14.3 percent on most major U.S. soda ash producers.[81] In October 1995, the European Commission, which could have imposed

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[79] Dennis Kostick, U.S. Bureau of Mines (USBM), *Annual Report, Soda Ash 1993*, Figure 2, p. 21. The U.S. Geological Survey took over the mineral information and data gathering responsibilities of the USBM in late 1995.

[80] Dennis Kostick, U.S. Bureau of Mines (USBM), *Annual Report, Soda Ash 1990*.

[81] *Industrial Minerals*, June 1995, p. 13.

duties for up to 5 years, voted to apply duties for a 1-year period and at a lower rate (ranging up to 8.9 percent) after which the need for a continuation of the duties was to be reviewed. In late 1997, following the withdrawal of support for the antidumping measures by several large European soda ash producers, the European Council terminated the EU antidumping duties.[82] The imposition of antidumping duties is believed to have had a significant impact in reducing U.S. exports of soda ash to the EU.[83]

Nontariff measures

In 1983 and in 1987, the Japan Fair Trade Commission (JFTC) found that the practices of the major Japanese soda ash producers and their affiliates violated the Japanese Anti-Monopoly Law, and these producers were ordered to cease these practices.[84] According to U.S. producers, the Japanese producers had set a quota on imports of soda ash and pressured Japanese distributors to limit their purchases of U.S. soda ash. According to a report issued by the United States Trade Representative (USTR), despite 10 years of investment by the U.S. soda ash industry in distribution and terminals in Japan and despite the fact that the cost structure of the U.S. soda ash industry is very competitive, the U.S. soda ash industry's share of the Japanese market held steady at not more than about 20 percent in 1995.[85] The failure to increase market share for U.S. soda ash producers in Japan was attributed to a continuation of noncompetitive practices in Japan. For example, according to the USTR report, Japanese consumers rejected offers by U.S. soda ash producers of steep discounts in exchange for increased purchases. According to an estimate by the U.S. soda ash industry, its annual sales to Japan would increase by about $15-$33 million were the Japanese market open to competitive imports.[86] According to an industry observer, U.S. concerns over alleged Japanese trade barriers have eased recently because of increased Japanese participation in the U.S. soda ash industry.

Trade sources indicate that nontariff trade barriers may exist in several countries. According to a source, U.S. soda ash producers are required to export to the EU individually rather than through the export trading company, ANSAC, because "the EC has ...disallowed ANSAC, as a cartel, to handle U.S. exports, leaving it to up to individual producers to seek business in Europe."[87] According to another source, the Indian Monopolies and Restrictive Trade Practices Commission, in response to a complaint by the Alkali Manufacturers Association of India, has also banned ANSAC (but not the individual U.S. soda ash companies) from exporting soda ash to India, on the ground that the ANSAC companies were operating as a cartel.[88]

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[82] *Chemical Week*, Oct. 29, 1997, p. 6.

[83] *Chemical Week*, Nov. 5, 1997, p. 13.

[84] United States Trade Representative, *1994 National Trade Estimate Report on Foreign Trade Barriers* and *1995 National Trade Estimate Report on Foreign Trade Barriers*, section on Japan.

[85] Ibid.

[86] Ibid.

[87] *Chemical Week*, Apr. 24, 1991, p. 12 and following.

[88] *Industrial Minerals*, June 1997, pp. 12, 17.

FOREIGN INDUSTRY PROFILE

The chloralkali chemicals are used in similar applications throughout the world, e.g., chlorine is used to make PVC and soda ash is used to make glass. As in the United States, production and consumption of the chloralkali chemicals in foreign countries are dominated by chlorine/caustic soda and soda ash.

Chlorine/Caustic Soda

Estimated chlorine production by region is summarized in figure 10.[89] The key players in the world chloralkali industry tend to be fairly stable, with some changes in ownership patterns. In developed countries, including countries in North America, Europe, and Japan, the chloralkali industries have seen rationalization in which small and inefficient plants have been shut down and replaced by large, technologically-advanced facilities. Unlike the United States, where diaphragm cell technology remains dominant, Europeans remain predominantly dependent on mercury cells, considered by some industry sources to be the most environmentally worrisome. In contrast, the Japanese industry has closed its mercury plants and now relies primarily on membrane cell technology, considered by many in the field to be the most advanced type of cell.

An emerging growth area is the Persian Gulf, where chemical producers are taking advantage of low energy costs and access to organic feedstocks such as ethylene to install chlorine/caustic soda plants and plants producing downstream petrochemical products. Chlorine/caustic soda producers in the Persian Gulf shipping to the Far East and Australia also enjoy lower freight rates relative to the United States. One source estimates that the cost difference is about $20 per dry ton. The Far East has included some of the fastest growing markets in the world. However, the impact of the recent economic crisis in Asia has adversely affected growth in these markets to varying degrees. Moreover, Japanese chlorine/caustic soda producers faced with a long-term recession are reportedly increasing exports of downstream products to regional markets at the expense of U.S. producers who are competitively handicapped because of higher freight charges.[90]

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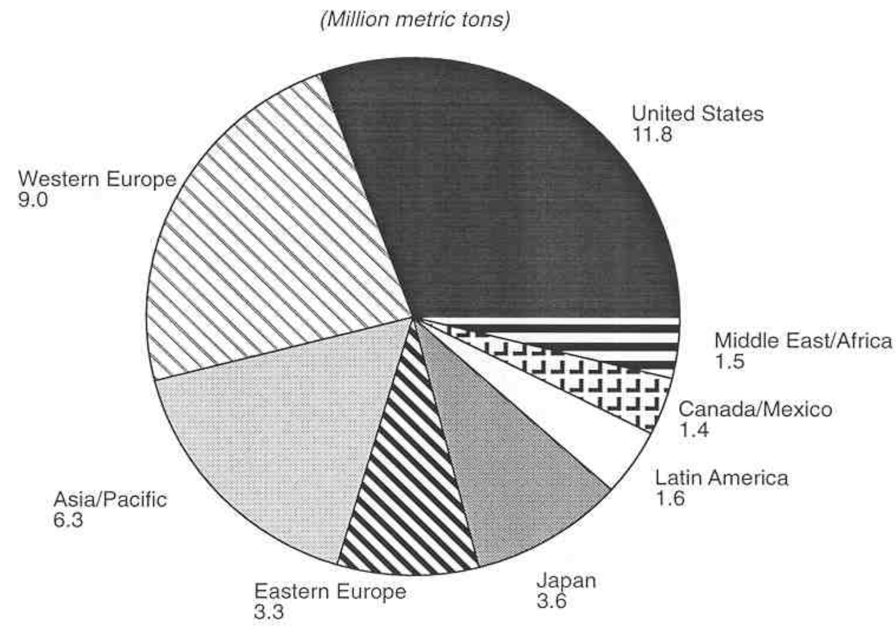
[89] Tecnon, 1996; presented at the *Chloralkali Industry Update and Forecast Conference*, May 29-30, 1996.

[90] *Chemical Market Reporter*, Jun. 9, 1997, pp. 7, 33.

Figure 10
World chlorine production by region, 1995



Total = 38.6 million metric tons

Source: Tecnon. Adapted from data presented at the Chloralkali Industry Update and Forecast Conference, May 29-30, 1996, reprinted with permission of Tecnon.

Recent industrial expansion in the Persian Gulf region includes a petrochemical complex in Jubail, Saudi Arabia, containing a chlorine/caustic soda plant. (Saudi Basic Industries Corp. (Sabic), a Saudi company, and Shell Oil Co., the large Dutch-based multinational energy company, are installing the facility.) Other Middle Eastern countries which are planning to increase their chlorine/caustic soda capacity include Iran and Qatar.

Chloralkali facilities in other developing countries tend to be smaller and less technologically advanced than in the developed world. Frequently, these operations involve joint ventures with companies in developed countries. Historically, the output of these plants has been geared to local captive consumption with little capacity remaining for export or for merchant markets.

Soda Ash

Major natural and synthetic soda operations are shown in figure 11. Listed below is reported or estimated soda ash production, ranked in descending order, in units of thousand metric tons, of some of the world's leading producing countries for 1992 and 1996:[91]

Source	1992	1996
United States	9,380	10,200
China	4,500	6,390
India	1,500	1,500
Russia	2,679	1,460
Germany	1,639	1,400
France	1,100	1,100
Japan	1,057	1,050
United Kingdom	1,000	1,000
Poland	929	1,000
Ukraine	1,000	425
World	30,700	30,400

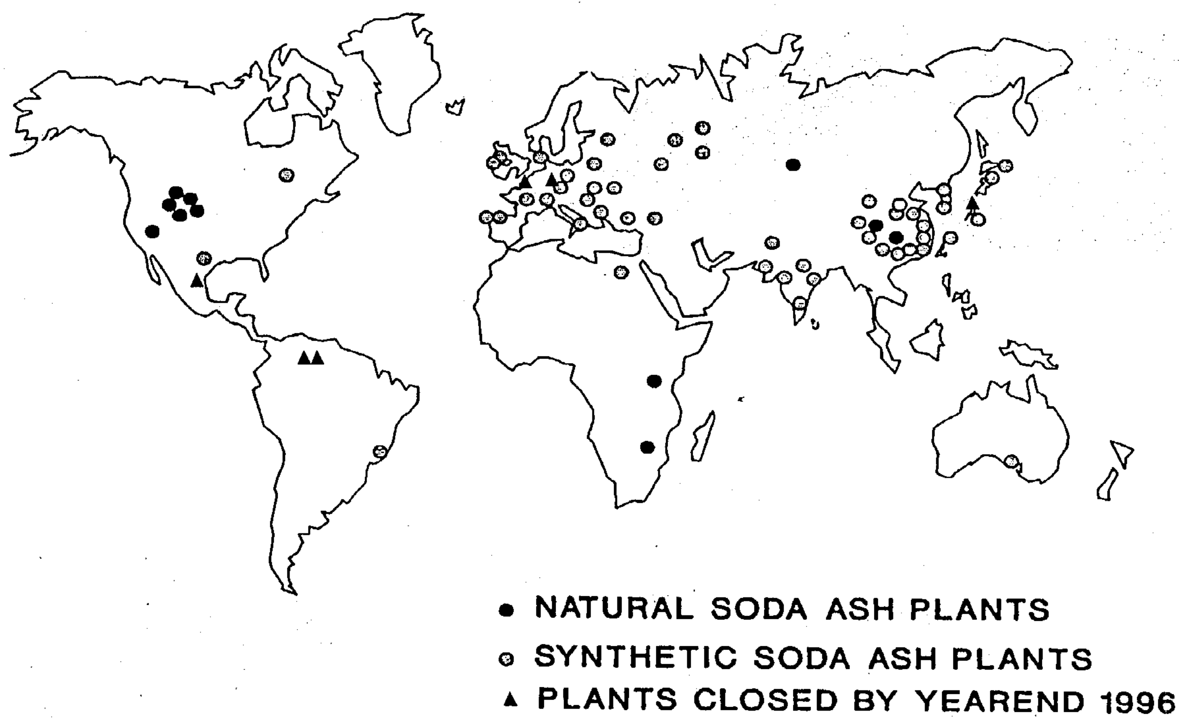
In contrast to the United States, which exclusively produces natural sodium carbonate, in most foreign countries only synthetic soda ash is produced. Some exceptions include Botswana, Kenya and China. China produces mostly synthetic soda ash but also some natural soda ash. Compared to the processes used to make natural soda ash in the United States, the synthetic process suffers from three major disadvantages: (1) it is about twice as costly; (2) it produces byproducts that are potentially harmful to the environment if not treated or recovered; and (3) the soda ash that is produced is less pure.[92] Some synthetic soda ash plants in the developed world have shut down, in part because of competition from low-cost U.S. exports of natural soda ash.[93] Despite its competitive disadvantages, the synthetic process remains cost-competitive with Wyoming soda ash in localities near the synthetic soda ash plants since long distance transportation costs for soda ash amount to a significant percentage of total cost.

[91] Dennis Kostick, U.S. Geological Survey: *Mineral Industry Surveys, Soda Ash, Annual Review-1996*.

[92] U.S. Geological Survey Official, interview by USITC staff, Apr. 13, 1998.

[93] For example, Tosoh Corp. closed its high-cost synthetic soda ash plant in Japan in 1996 and will obtain soda ash from U.S. imports. Tosoh Corp. is involved in a partnership with General Chemical Corp., a natural soda ash producer with facilities in Green River, WY. (*Chemical Marketing Reporter*, Aug. 14, 1995, p. 5.)

Figure 11
Major natural and synthetic soda ash operations in the world, 1996



Source: U.S. Geological Survey.

Per capita, soda ash is used much more intensively in the developed world than in developing countries. However, the growth rates for soda ash consumption and production are expected to be higher in the developing world where uses for soda ash, such as in glass, are expected to grow more rapidly than in the developed countries. China has emerged as one of the fastest growing producers of soda ash and may become a major competitor of U.S. exporters. In contrast, soda ash production in the former Soviet Union, especially in Russia and Ukraine, has reportedly declined significantly as privatization proceeds and as these countries struggle to move toward a market economy.

APPENDIX A
EXPLANATION OF TARIFF AND TRADE AGREEMENT TERMS

TARIFF AND TRADE AGREEMENT TERMS

In the ***Harmonized Tariff Schedule of the United States*** (HTS), chapters 1 through 97 cover all goods in trade and incorporate in the tariff nomenclature the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description. Subordinate 8-digit product subdivisions, either enacted by Congress or proclaimed by the President, allow more narrowly applicable duty rates; 10-digit administrative statistical reporting numbers provide data of national interest. Chapters 98 and 99 contain special U.S. classifications and temporary rate provisions, respectively. The HTS replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989.

Duty rates in the ***general*** subcolumn of HTS column 1 are most-favored-nation (now referred to as normal trade relations) rates, many of which have been eliminated or are being reduced as concessions resulting from the Uruguay Round of Multilateral Trade Negotiations. Column 1-general duty rates apply to all countries except those listed in HTS general note 3(b) (Afghanistan, Cuba, Laos, North Korea, and Vietnam), which are subject to the statutory rates set forth in ***column 2***. Specified goods from designated general-rate countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the ***special*** subcolumn of HTS rate of duty column 1 or in the general notes. If eligibility for special tariff rates is not claimed or established, goods are dutiable at column 1-general rates. The HTS does not enumerate those countries as to which a total or partial embargo has been declared.

The ***Generalized System of Preferences*** (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 for 10 years and extended several times thereafter, applies to merchandise imported on or after January 1, 1976 and before the close of June 30, 1999. Indicated by the symbol "A", "A*", or "A+" in the special subcolumn, the GSP provides duty-free entry to eligible articles the product of and imported directly from designated beneficiary developing countries, as set forth in general note 4 to the HTS.

The ***Caribbean Basin Economic Recovery Act*** (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984. Indicated by the symbol "E" or "E*" in the special subcolumn, the CBERA provides duty-free entry to eligible articles, and reduced-duty treatment to certain other articles, which are the product of and imported directly from designated countries, as set forth in general note 7 to the HTS.

Free rates of duty in the special subcolumn followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free Trade Area Implementation Act*** of 1985 (IFTA), as provided in general note 8 to the HTS.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the ***Andean Trade Preference Act*** (ATPA), enacted as title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 11 to the HTS.

Preferential free rates of duty in the special subcolumn followed by the symbol "CA" are applicable to eligible goods of Canada, and rates followed by the symbol "MX" are applicable to eligible goods of Mexico, under the ***North American Free Trade Agreement***, as provided in general note 12 to the HTS and implemented effective January 1, 1994 by Presidential Proclamation 6641 of December 15, 1993. Goods must originate in the NAFTA region under rules set forth in general note 12(t) and meet other requirements of the note and applicable regulations.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), ***products of the West Bank and Gaza Strip*** (general note 3(a)(v)), goods covered by the ***Automotive Products Trade Act*** (APTA) (general note 5) and the ***Agreement on Trade in Civil Aircraft*** (ATCA) (general note 6), ***articles imported from freely associated states*** (general note 10), ***pharmaceutical products*** (general note 13), and ***intermediate chemicals for dyes*** (general note 14).

The ***General Agreement on Tariffs and Trade 1994*** (GATT 1994), pursuant to the Agreement Establishing the World Trade Organization, is based upon the earlier GATT 1947 (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) as the primary multilateral system of disciplines and principles governing international trade. Signatories' obligations under both the 1994 and 1947 agreements focus upon most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, antidumping and countervailing duties, dispute settlement, and other measures. The results of the Uruguay Round of multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX. Pursuant to the **Agreement on Textiles and Clothing** (ATC) of the GATT 1994, member countries are phasing out restrictions on imports under the prior "Arrangement Regarding International Trade in Textiles" (known as the **Multifiber Arrangement** (MFA)). Under the MFA, which was a departure from GATT 1947 provisions, importing and exporting countries negotiated bilateral agreements limiting textile and apparel shipments, and importing countries could take unilateral action in the absence or violation of an agreement. Quantitative limits had been established on imported textiles and apparel of cotton, other vegetable fibers, wool, man-made fibers or silk blends in an effort to prevent or limit market disruption in the importing countries. The ATC establishes notification and safeguard procedures, along with other rules concerning the customs treatment of textile and apparel shipments, and calls for the eventual complete integration of this sector into the GATT 1994 over a ten-year period, or by Jan. 1, 2005.

APPENDIX B
GLOSSARY OF TERMS[1]

[1] Derived from a variety of sources including chemical references.

GLOSSARY OF TERMS

Alkali: A group of substances which share similar chemical properties such as the ability to neutralize acids and to turn litmus paper blue (also referred to as a base). Chemically an alkali is defined as a substance whose pH is greater than 7.0.

Alkaline: The similar chemical properties exhibited by alkali substances (also referred to as basic).

Brine: A solution of sodium chloride in water.

Caustic potash (**potassium hydroxide**): A corrosive alkali chemical with chemical properties similar to caustic soda, prepared by the electrolysis of potassium chloride.

Caustic soda (sodium hydroxide): A corrosive alkali chemical, usually prepared by the electrolysis of salt, used in the neutralization of acids and in the preparations of many organic and inorganic chemicals.

Chemical caustic: caustic soda that is prepared from a chemical process. The production of chemical caustic would not require the electrolysis of salt nor would chlorine be generated as a co-product. The lime soda process in which soda ash is reacted with lime to generate caustic soda is employed by several U.S. soda ash producers.

Chlorine: A dense greenish gas, prepared by the electrolysis of salt, used as an oxidizing agent and in the manufacture of many organic and inorganic chemicals.

Chlorofluorocarbons (CFCs): Certain compounds of carbon, chlorine, fluorine, and hydrogen whose use has been largely banned because these compounds react destructively with atmospheric ozone.

Deliquescent: The properties manifested by certain solids to absorb water from the atmosphere to such a degree that the solid tends to eventually dissolve in the water absorbed from the air.

Electrochemical unit (ECU): A unit of quantity corresponding to one ton of chlorine and 1.1 ton of co-product caustic soda. The 1:1.1 ratio corresponds to the relative quantities of chlorine and caustic soda produced in the electrolysis of aqueous sodium chloride. The ECU price provides a useful measure of determining how the combined price of chlorine and caustic soda compares to the cost of production which is largely the electricity required in the electrolysis of sodium chloride.

Ethylene dichloride (EDC): An organic chemical produced by the reaction of ethylene and chlorine that is used to produce vinyl chloride monomer (VCM) from which polyvinyl plastics are produced.

Hygroscopic: The properties manifested by certain solids to absorb water from the atmosphere.

Oxidizing agent: A substance that tends to react chemically with other materials by attracting electrons.

Polyvinyl chloride (PVC): A synthetic thermoplastic polymer used in many plastic applications including construction-related items such as siding, piping, and conduits.

Potassium carbonate: A white powder prepared from potassium chloride and limestone, used in the preparation of optical and color TV screens.

Potassium hydroxide: See caustic potash.

Soda ash (sodium carbonate): An inorganic chemical used for its alkaline properties and as a source of sodium oxide in the manufacture of glass, chemicals, and detergents.

Soda ash, dense: Soda ash having a bulk density of about 1 g/ml or higher.

Soda ash, intermediate: Soda ash having a bulk density of about 0.8 g/ml.

Soda ash, light: Soda ash having a bulk density of about 0.6 g/ml or lower.

Sodium bicarbonate (baking soda): A mild alkali prepared principally from soda ash and used in many industrial and household products.

Sodium carbonate: See soda ash.

Sodium hydroxide: See caustic soda.

Solvay process: In this synthetic process, soda ash is produced by reacting carbon dioxide gas (derived from calcined limestone) with brine containing ammonia. Upon filtering and calcining the sodium bicarbonate that is produced, soda ash is formed. Outside the United States, the Solvay process is the most common process for manufacturing soda ash. There are several variations of this process.

Synthetic chemical or **synthetic process**: A synthetic chemical is generally defined as a chemical which is produced from starting materials which are reacted chemically. Similarly, a synthetic process is generally defined as a process in which the starting materials are reacted chemically so as to form a product; the reaction must be sufficiently energetic so that chemical bonds are made or broken.

Trona: The principal ore, composed of sodium carbonate, sodium bicarbonate, and water, from which natural soda ash is made.

Vinyl chloride monomer (VCM): An organic chemical made from ethylene dichloride (EDC) that is used to produce polyvinyl chloride (PVC) plastics.

APPENDIX C
TABLES

Table C-1
Chlorine: U.S. imports for consumption, by principal sources, 1992-97[1]

Source	1992	1993	1994	1995	1996	1997
	Quantity (1,000 kilograms)					
Canada	247,069	291,384	338,071	313,615	327,655	372,129
Mexico	0	1,000	18,982	45,860	52,165	38,578
Japan	1	13	4	8	7	4
France	1	([2])	([2])	8	61	19
Belgium	0	752	0	0	0	([2])
All other	2,796	237	379	83	29	([2])
Total	249,866	293,387	357,435	359,574	379,917	410,731
	Value (1,000 dollars)					
Canada	18,262	23,447	40,044	41,486	37,446	56,732
Mexico	0	150	1,504	2,212	2,861	4,088
Japan	73	281	201	269	283	228
France	18	24	16	21	29	22
Belgium	0	73	0	0	0	10
All other	439	58	87	53	19	2
Total	18,792	24,033	41,852	44,042	40,638	61,083
	Unit value (per 1,000 kilograms)					
Canada	$73.91	$80.47	$118.45	$132.28	$114.29	$152.45
Mexico	([3])	150.00	79.23	48.24	54.84	105.98
Japan	([4])	([4])	([4])	([4])	([4])	([4])
France	([4])	([4])	([4])	([4])	([4])	([4])
Belgium	([3])	97.50	([3])	([3])	([3])	([4])
All other	156.87	244.56	229.05	645.67	655.35	([4])
World average	75.21	81.92	117.09	122.48	106.96	148.72

[1] Because of rounding, numbers may not add to totals shown.
[2] Less than 500 kilograms.
[3] Not meaningful.
[4] Apparent discrepancy in data.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-2
Caustic soda in aqueous solution: U.S. imports for consumption, by principal sources, 1992-97[1]

Source	1992	1993	1994	1995	1996	1997
	Quantity (1,000 kilograms of contained weight)					
Canada	261,400	239,408	200,326	224,306	228,650	215,221
Belgium	35,072	27,243	62,830	55,254	105,355	86,062
France	60,528	88,739	99,378	81,676	78,438	77,859
Saudi Arabia	14,185	5,982	0	11,867	7,654	26,358
Germany	4,200	4,329	11,309	8,365	16,967	9,549
Brazil	22,728	18,536	3,310	8,381	10,449	311
United Kingdom	16,165	29,574	8,605	11,230	2,151	5,718
Venezuela	0	0	0	0	3,988	6,871
Mexico	0	0	7,276	5,081	1,727	3,127
All other	85,198	29,850	69,256	37,824	34,363	8,442
Total	499,476	443,661	462,291	443,985	489,741	439,517
	Value (1,000 dollars)					
Canada	54,293	36,981	30,756	53,862	55,843	39,821
Belgium	7,608	3,333	9,253	13,147	18,013	11,055
France	16,242	10,776	10,272	16,426	14,248	9,917
Saudi Arabia	4,877	1,164	0	3,769	1,483	3,922
Germany	1,412	2,063	3,038	3,711	3,038	2,691
Brazil	5,916	3,237	749	2,532	2,822	1,885
United Kingdom	3,999	3,059	1,008	3,580	327	1,335
Venezuela	0	0	0	0	771	947
Mexico	0	0	1,351	1,022	270	602
All other	25,580	4,838	17,428	13,175	7,932	1,443
Total	119,927	65,452	73,856	111,224	104,746	73,616
	Unit value (per kilogram of contained weight)					
Canada	$0.208	$0.154	$0.154	$0.240	$0.244	$0.185
Belgium	0.217	0.122	0.147	0.238	0.171	0.128
France	0.268	0.121	0.103	0.201	0.182	0.127
Saudi Arabia	0.344	0.195	([1])	0.318	0.194	0.149
Germany	0.336	0.477	0.269	0.444	0.179	0.282
Brazil	0.260	0.175	0.226	0.302	0.270	6.057
United Kingdom	0.247	0.103	0.117	0.319	0.152	0.233
Venezuela	([2])	([2])	([2])	([2])	0.193	0.138
Mexico	([2])	([2])	0.186	0.201	0.156	0.192
All other	0.300	0.162	0.252	0.348	0.231	0.171
World average	0.240	0.148	0.160	0.251	0.214	0.167

[1] Because of rounding, numbers may not add to totals shown.

[2] Not meaningful.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-3
Caustic potash: U.S. imports for consumption, by principal sources, 1992-97[1]

Source	1992	1993	1994	1995	1996	1997
	Quantity (1,000 kilograms)					
Sweden	745	927	886	999	2,615	1,049
Germany	22	19	2,352	5,451	8,412	6,591
Italy	500	320	1,012	2,830	1,172	4,972
Canada	12,655	14,455	44,177	8,307	12,349	14,444
Mexico	312	580	465	1,029	716	3,607
France	11	11	37	81	158	2,862
Czech Republic[2]	35	31	118	149	244	171
Netherlands	0	20	0	59	1,041	71
United Kingdom	4,930	1,033	22	11	9	45
All other	38	28,786	932	188,840	125	35
Total	19,214	46,183	50,002	207,757	26,842	33,848
	Value (1,000 dollars)					
Sweden	1,771	2,184	2,192	2,616	2,909	3,098
Germany	27	17	509	1,385	2,644	2,231
Italy	260	161	466	740	517	2,133
Canada	1,715	2,109	3,270	597	1,746	1,092
Mexico	178	347	271	629	480	679
France	18	18	49	52	115	502
Czech Republic[2]	35	39	140	172	264	206
Netherlands	0	11	0	24	570	160
United Kingdom	840	265	122	91	79	125
All other	48	2,243	366	13,940	83	54
Total	4,858	7,394	7,385	20,246	9,408	10,280
	Unit value (per kilogram)					
Sweden	$2.377	$2.355	$2.473	$2.620	$1.112	$2.953
Germany	1.226	0.876	0.217	0.254	0.314	0.338
Italy	0.521	0.502	0.460	0.262	0.441	0.429
Canada	0.136	0.146	0.074	0.072	0.141	0.076
Mexico	0.573	0.599	0.583	0.611	0.671	0.188
France	1.538	1.574	1.310	0.640	0.725	0.175
Czech Republic[2]	1.02	1.260	1.183	1.159	1.080	1.205
Netherlands	([3])	0.560	([3])	0.400	0.548	2.244
United Kingdom	0.170	0.257	5.588	8.171	8.833	2.749
All other	1.257	0.078	0.393	0.074	0.666	1.569
World average	0.253	0.160	0.148	0.097	0.350	0.304

[1] Because of rounding, numbers may not add to totals shown.
[2] In 1992, included imports from the former Czechoslovakia.
[3] Not meaningful.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-4
Soda ash: U.S. exports of domestic merchandise, by principal markets, 1992-97[1]

Market	1992	1993	1994	1995	1996	1997
			Quantity (1,000 kilograms)			
Indonesia	220,397	236,844	284,038	343,324	413,593	395,892
Japan	262,412	353,145	340,119	339,412	326,627	435,175
Mexico	161,723	190,137	342,921	397,176	367,046	467,749
Korea	252,322	237,461	341,213	276,836	310,784	306,251
Thailand	148,624	104,896	195,423	263,259	284,580	248,091
Taiwan	128,118	122,739	187,890	198,298	181,953	207,627
Brazil	82,485	88,803	167,370	232,622	209,402	183,139
Canada	135,835	120,092	149,654	186,788	235,803	248,493
Chile	75,029	59,153	59,439	78,037	122,577	156,084
All other	1,487,779	1,285,177	1,123,737	1,256,870	1,385,047	1,381,524
Total	2,954,723	2,798,446	3,191,804	3,572,622	3,837,411	4,030,024
			Value (1,000 dollars)			
Indonesia	31,511	31,768	36,710	46,586	59,699	57,042
Japan	36,491	49,512	47,745	41,812	43,236	56,181
Mexico	25,717	21,481	31,748	35,908	39,577	54,041
Korea	39,368	34,595	46,575	39,300	45,890	45,310
Thailand	21,227	13,720	25,858	35,999	41,330	35,615
Taiwan	18,380	16,696	24,482	26,575	26,171	28,872
Brazil	12,693	10,240	18,256	31,366	27,270	24,403
Canada	15,984	13,121	13,495	15,669	21,838	22,953
Chile	11,471	8,035	7,893	10,511	16,966	21,585
All other	220,763	177,039	150,493	161,660	186,343	181,310
Total	433,606	376,206	403,256	445,386	508,319	527,312
			Unit value (per kilogram)			
Indonesia	$0.143	$0.134	$0.129	$0.136	$0.144	$0.144
Japan	0.139	0.140	0.140	0.123	0.132	0.129
Mexico	0.159	0.113	0.093	0.090	0.108	0.116
Korea	0.156	0.146	0.136	0.142	0.148	0.148
Thailand	0.143	0.131	0.132	0.137	0.145	0.144
Taiwan	0.143	0.136	0.130	0.134	0.144	0.139
Brazil	0.154	0.115	0.109	0.135	0.130	0.133
Canada	0.118	0.109	0.090	0.084	0.093	0.092
Chile	0.153	0.136	0.133	0.135	0.138	0.138
All other	0.148	0.138	0.134	0.129	0.135	0.131
World average	0.147	0.134	0.126	0.125	0.132	0.131

[1] Because of rounding, numbers may not add to totals shown.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-5
Caustic soda in aqueous solution: U.S. exports of domestic merchandise, by principal markets, 1992-97[1]

Market	1992	1993	1994	1995	1996	1997
	Quantity (1,000 kilograms of contained weight)					
Canada	206,641	128,164	264,390	386,784	457,099	375,918
Venezuela	99,404	176,633	80,123	79,652	116,820	159,050
Brazil	45,412	10,083	34,836	43,435	95,841	133,381
Jamaica	117,509	83,885	48,558	223,859	292,131	126,957
Suriname	94,963	51,355	19,275	152,355	133,521	82,137
Australia	305,856	221,596	68,462	391,563	325,847	106,801
Mexico	38,100	5,951	12,409	27,607	83,602	56,292
Colombia	44,713	24,612	57,857	72,356	55,501	37,946
Belgium	3,742	130	1,658	21,336	20,205	34,415
All other	107,115	81,945	116,304	237,972	254,966	203,152
Total	1,063,455	784,353	703,873	1,636,919	1,835,533	1,316,049
	Value (1,000 dollars)					
Canada	46,286	43,277	42,194	79,750	99,144	76,764
Venezuela	30,553	12,354	12,464	27,826	26,971	22,856
Brazil	11,139	1,718	5,351	7,261	20,589	18,568
Jamaica	28,100	13,907	7,474	55,021	57,352	18,236
Suriname	23,170	12,385	4,688	39,410	28,556	14,416
Australia	66,919	32,666	7,557	89,741	67,707	13,594
Mexico	11,479	3,223	3,183	4,726	13,521	7,581
Colombia	10,994	3,459	10,973	14,008	9,084	5,592
Belgium	608	78	374	2,894	2,445	3,642
All other	31,515	17,119	25,178	49,248	46,684	26,728
Total	260,763	140,187	119,436	369,884	372,053	207,978
	Unit value (per kilogram of contained weight)					
Canada	$0.224	$0.338	$0.160	$0.206	$0.217	$0.204
Venezuela	0.307	0.070	0.156	0.349	0.231	0.144
Brazil	0.245	0.170	0.154	0.167	0.215	0.139
Jamaica	0.239	0.166	0.154	0.246	0.196	0.144
Suriname	0.244	0.241	0.243	0.259	0.214	0.176
Australia	0.219	0.147	0.110	0.229	0.208	0.127
Mexico	0.301	0.542	0.256	0.171	0.162	0.135
Colombia	0.246	0.141	0.190	0.194	0.164	0.147
Belgium	0.163	0.600	0.226	0.136	0.121	0.106
All other	0.294	0.209	0.216	0.207	0.183	0.132
World average	0.245	0.179	0.170	0.226	0.203	0.158

[1] Because of rounding, numbers may not add to totals shown.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-6
Caustic potash: U.S. exports of domestic merchandise, by principal markets, 1992-97[1]

Market	1992	1993	1994	1995	1996	1997
	Quantity (1,000 kilograms)					
Canada	8,696	9,424	8,583	14,409	15,023	15,741
Mexico	5,354	3,167	1,525	2,007	1,418	3,449
Belgium	14,745	18,780	14,024	14,792	10,818	29,598
Japan	6,595	4,937	11,734	24,378	30,892	10,628
Israel	2,513	1,203	275	162	375	175
Australia	837	734	341	2,439	4,109	4,037
United Kingdom	4,322	8,391	5,499	3,915	4,488	5,664
China	1,497	1,725	1,000	438	1,913	1,197
Singapore	454	260	498	591	673	810
All other	50,010	8,907	11,254	15,487	9,917	10,321
Total	95,023	57,527	54,732	78,616	79,626	81,619
	Value (1,000 dollars)					
Canada	3,248	3,607	4,209	6,715	6,594	7,284
Mexico	3,320	2,847	3,380	3,566	3,800	5,292
Belgium	4,888	3,658	3,159	3,391	2,127	4,750
Japan	1,766	992	2,347	4,822	4,499	2,163
Israel	686	506	179	103	245	1,308
Australia	382	381	189	570	1,153	1,038
United Kingdom	1,621	2,987	1,237	978	1,520	993
China	704	857	544	255	1,141	744
Singapore	279	178	266	304	508	561
All other	22,923	5,486	5,005	8,067	6,870	4,566
Total	39,817	21,500	20,516	28,770	28,458	28,699
	Unit value (per kilogram)					
Canada	$0.373	$0.383	$0.490	$0.466	$0.439	$0.463
Mexico	0.620	0.899	2.217	1.776	2.681	1.534
Belgium	0.332	0.195	0.225	0.229	0.197	0.160
Japan	0.268	0.201	0.200	0.198	0.146	0.204
Israel	0.273	0.421	0.650	0.633	0.653	7.486
Australia	0.457	0.519	0.554	0.234	0.281	0.257
United Kingdom	0.375	0.356	0.225	0.250	0.339	0.175
China	0.470	0.497	0.545	0.582	0.596	0.622
Singapore	0.613	0.688	0.534	0.515	0.755	0.692
All other	0.458	0.616	0.445	0.521	0.693	0.442
World average	0.419	0.374	0.375	0.366	0.357	0.352

[1] Because of rounding, numbers may not add to totals shown.

Source: Compiled from official statistics of the U.S. Department of Commerce.